# Non-adherence to Prescribed Home Exercise in Chronic Low Back Pain

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# Non-adherence to Prescribed Home Exercise in Chronic Low Back Pain

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## Abstract

**Background:** Adherence to prescribed home exercise for chronic low back pain (CLBP) is poor and this remains an under-researched area. There is no standard measure of exercise adherence and traditional health behaviour models are limited in their ability to explain non-adherence. This thesis aims to address these issues.

**Aim:** To undertake a review of CLBP literature (Study 1), to develop a new measure (Study 2) and to investigate the role of psychosocial, clinical and executive function factors in explaining variation in exercise adherence in CLBP (Study 3).

**Design:** Study 1 involved systematically reviewing factors associated with adherence to prescribed home exercise in CLBP. In Study 2, the Exercise Adherence Rating Scale (EARS) was developed. Study 3 was a prospective observational study of exercise adherence in a CLBP sample.

**Results:** Study 1 found nine trials providing moderate evidence that higher health locus of control, supervision, participation in an exercise programme and participation in a behaviour change programme incorporating motivational strategies were associated with better exercise adherence in CLBP samples. In Study 2, a 1-factor solution explained 66% of the variance in adherence to exercise. Internal consistency ($\alpha = 0.758$) and item-response theory methods indicated that EARS reliability was acceptable. In Study 3, longer duration of pain, higher present pain, lower educational level and being female significantly predicted poor adherence behaviour. Executive functions were not predictive of adherence behaviour.

**Conclusions:** Study 1 highlighted a lack of good quality evidence and standardised measures of adherence. The EARS in Study 2 provided a valid and reliable assessment of adherence behaviour in a CLBP sample and now requires further testing. Results of Study 3 suggested factors influencing adherence to prescribed home exercise in patients with CLBP. The inclusion of these factors within health behaviour models may provide better explanatory models of exercise behaviour in CLBP.

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## Abbreviations and Symbols

| | |
|---|---|
| **ANOVA** | Analysis of Variance |
| **APA** | American Psychological Association |
| **ASD** | Autistic Spectrum Disorder |
| **B** | Unstandardised Regression Coefficient |
| **β** | Standardised Regression Coefficient |
| **BCP** | Behaviour Change Programme |
| **BDI** | Beck Depression Inventory |
| **BeST** | The Back Skills Training trial |
| **BMI** | Body Mass Index |
| **Brief IPQ** | Brief Illness Perception Questionnaire |
| **BW Digit Span** | Backwards Digit Span test |
| **CDR** | Computerized Assessment System |
| **CFA** | Confirmatory Factor Analysis |
| **Cronbach's α** | Cronbach's alpha |
| **CLBP** | Chronic Low Back Pain |
| **CSP** | Chartered Society of Physiotherapy |
| **d** | Cohen's d |
| **DLPFC** | Dorsolateral Prefrontal Cortex |
| **EARS** | Exercise Adherence Rating Scale |
| **EFA** | Exploratory Factor Analysis |
| **ES** | Effect Size |
| **FABQ** | Fear-avoidance Beliefs Questionnaire |
| **FCS** | Fully Conditional Specification |
| **GP** | General Practitioner |
| **HADS** | Hospital Anxiety and Depression Scale |
| **HBM** | Health Belief Model |
| **HCP** | Healthcare Provider |
| **HSCT** | Hayling Sentence Completion Test |
| **IQ** | Intelligence |
| **IRT** | Item Response Theory |
| **LBP** | Low Back Pain |
| **LOCF** | Last Observation Carried Forward |
| **MAR** | Missing At Random |

| | |
|---|---|
| **MCAR** | Missing Completely at Random |
| **MCMC** | Markov Chain Monte Carlo method |
| **MI** | Multiple Imputation |
| **MICE** | Multiple Imputation by Chained Equations |
| **MNAR** | Missing Not at Random |
| **MSK** | Musculoskeletal |
| **MTMM** | Multitrait-multimethod data |
| **MVA** | Missing Value Analysis |
| **n** | Number in sample |
| **NART** | National Adult Reading Test |
| **NHS** | National Health Service |
| **NICE** | National Institute for Health and Care Excellence |
| **NRS** | Neurobehavioral Rating Scale |
| **OECD** | Organisation for Economic Co-operation and Development |
| **PA** | Parallel Analysis |
| **PBC** | Perceived Behavioural Control |
| **PEQ** | Prescribed Exercise Questionnaire |
| **PET** | Positron Emission Tomography |
| **PRISMA** | Preferred Reporting Items for Systematic reviews and Meta-Analyses |
| **PT** | Physiotherapy |
| **QAT** | Quality Assessment Tool |
| **r** | Pearson's product-moment correlation |
| **RCT** | Randomised Controlled Trial |
| **RMDQ** | Roland-Morris Disability Questionnaire |
| **RNG** | Random Number Generation test |
| **rpb** | Point-biserial correlation |
| **SBST** | STarT Back Screening Tool |
| **SD** | Standard Deviation |
| **SDT** | Self-determination Theory |
| **SE B** | Standard Error of Beta |
| **SEM** | Structured Equation Modelling |
| **SF-McGill** | Short-form McGill Pain Questionnaire |
| **Sig.** | Significance value |
| **SIGN** | Scottish Intercollegiate Guidelines Network |

| | |
|---|---|
| **SPIRIT** | Standard Protocol Items: Recommendations for Interventional Trials |
| **SPSS** | Statistical Package for the Social Sciences |
| **Stroop C-W test** | Stroop Colour-Word test |
| **t** | the t statistic |
| **ToH** | Tower of Hanoi test |
| **TPB** | Theory of Planned Behaviour |
| **TST** | Temporal Self-regulation Theory |
| **TTM** | Transtheoretical Model |
| **$U_3$** | Cohen's U |
| **UK** | United Kingdom |
| **WCST** | Wisconsin Card Sorting Test |
| **WHO** | World Health Organisation |
| **WRAT** | Wide Range Achievement Test |
| **WTAR** | Wechsler Test of Adult Reading |
| **$\chi^2$** | Chi squared value |
| **$\dot{x}$** | Mean |

## Glossary

| | |
|---|---|
| **Adherence behaviour** | Extent to which a person's behaviour corresponds with home exercise recommendations from a healthcare provider. |
| **Attrition** | Participant drop-out after enrolment in a study. |
| **Low back pain** | Duration of low back pain for less than 12 weeks. |
| **Chronic low back pain** | Duration of LBP for 12 weeks or more. |
| **Dorsolateral Prefrontal Cortex** | Part of the prefrontal cortex of the brain. |
| **Executive functions** | Operations of the brain that enable effortful or 'top-down' control of behaviour. |
| **Fully Conditional Specification** | A multiple imputation algorithm where an imputation model is specified for each missing value. |
| **Health Locus of Control** | Extent to which a person attributes their health to their own actions or the actions of others. |
| **Hydrotherapy** | Therapeutic exercises performed in a heated pool. |
| **Item Response Theory** | A set of latent variable models that explain the process by which individuals respond to items on a questionnaire. |
| **Kurtosis** | Peakedness of data relative to a normal distribution. |
| **Latent variable** | Variables that are inferred, rather than being directly observable (e.g. adherence behaviour). |
| **Listwise deletion** | Analysis of only complete sets of data in a dataset. |
| **Multiple Imputation by Chained Equations** | Software for imputing missing data by Fully Conditional Specification. |
| **Prescribed home exercise** | Prescribed therapeutic exercises performed outside of the clinic setting. |
| **Skewness** | Described the asymmetry of a set of data relative to a normal distribution. |
| **Taxonomy of behaviour change techniques** | A system of classification and standardisation of behaviour change techniques. |
| **Triage** | An initial face-to-face or telephone consultation to determine the best course of treatment for a patient. |

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## Dedication

*For my Ocean,*

*Born 10th February 2014*

## Peer-reviewed publications arising from this thesis to date

Beinart, N., Goodchild, C., Weinman, J., Ayis, S., & Godfrey, E. (2013). Individual and intervention-related factors associated with adherence to home exercise in chronic low back pain: a systematic review. *Spine, (13)12,* 1940-1950.

This publication forms part of Chapter 3

## Preface

Back pain became a significant research field after Barr (as cited in Benzel, 2012) removed a disc hernia from a patient's lower back and realised that this was one of many potential causes of chronic low back pain (CLBP). Journals focusing solely on back-related research became established in the mid-1970s and forty years on, our knowledge on the deleterious effects and treatment of CLBP have advanced significantly. For example, Nachemson (1976) cites one of the first 'back schools', a 4 hour video together with exercise treatment, developed to help people with CLBP. Back schools are still recommended as treatment for some people with CLBP. However, decades of research have provided information to help improve treatment so that back schools are now delivered over a period of time (e.g. 6 weeks) and may include supervised and unsupervised prescribed exercise, education and pain management components (Arthritis and Musculoskeletal Alliance, 2004).

Prescribed exercise has been acknowledged as a key component of CLBP treatment since the 1970s (van Middelkoop et al., 2010; Zachrisson, 1972). However, only in recent years has exercise treatment been revealed to be an effective treatment for CLBP (van Middelkoop et al., 2011; Liddle et al., 2004). Nevertheless, up to 70 percent of people with CLBP do not do their prescribed home exercises, leading to poor outcomes (e.g. higher pain and disability) (Harkapaa, Jarvikoski, Mellin, Hurri, & Luoma, 1991; Reilly, Lovejoy, Williams, & Roth, 1989). There is a research gap in the area of adherence to prescribed home exercise in general, and in CLBP in particular. The implication of this lack of research has been a difficulty building an evidence base for interventions to encourage adherence to prescribed home exercise. This thesis consists of three studies that aim to addresses this research gap by assessing why many people with CLBP do not adhere to their prescribed home exercises. Study 1 is a systematic review that identifies factors found to influence adherence to prescribed home exercise in previous CLBP research. Study 2 involves the development of a measure to assess adherence behaviour in CLBP. Study 3 investigates factors predicting prescribed home exercise in a CLBP sample. It is anticipated that information yielded will help improve understanding of the multitude of factors that may influence adherence to prescribed home exercise in CLBP.

## Structure of Thesis

- Chapter 1 introduces the scale of the problem of CLBP for adults in the UK and the issue of non-adherence to prescribed exercise in CLBP.
- Chapter 2 discusses the importance of methodological considerations when investigating exercise adherence behaviour in CLBP.
- Chapter 3 presents a systematic review assessing factors associated with adherence to home exercise in CLBP (Study 1).
- Chapter 4 describes the initial development and psychometric evaluation of a measure to assess adherence to prescribed home exercise (Study 2; The Exercise Adherence Rating Scale - EARS).
- Chapter 5 presents a protocol that discusses methods and measures used to investigate executive function, psychosocial and clinical factors and their relationship with adherence to prescribed home exercise in CLBP (Study 3).
- Chapter 6 presents methods of baseline data analysis and discusses the baseline results of Study 3.
- Chapter 7 presents methods of follow-up data analysis and discusses the follow-up results of Study 3.
- Chapter 8 synthesises the preceding chapters, including an interpretation of the research presented in Chapters 3 to 7. Implications of the research and directions for future research are discussed. Finally, overall conclusions of this thesis investigating adherence to prescribed home exercise in CLBP are presented.

# 1. Exercise Adherence Behaviour in Chronic Low Back Pain

## Overview

This chapter consists of five main sections which discuss the research relevant to this thesis. The first section introduces CLBP and its substantial impact on the individual, the NHS and society (1.1.). The second section introduces the issue of exercise non-adherence and reasons that individuals with CLBP may find it difficult to adhere to prescribed home exercise (1.2.). The third section discusses models of behaviour change that have been used to explain and predict exercise behaviour (1.3.). The fourth section discusses evidence of neurological changes and executive function deficits in CLBP (1.4.). The last section brings together the previous four sections by introducing five research objectives and one hypothesis relevant to the three studies conducted for this thesis (1.5).

## 1.1. CLBP: a statement of the problem

This chapter begins by describing different definitions and categorisations of CLBP that have been used by pain researchers and healthcare organisations (1.1.1.). This is followed by a discussion of the problem of CLBP and its substantial impact on the individual, the NHS and society (1.1.2.). Difficulties in determining a cause of CLBP is then debated through exploration of key psychosocial factors that have been implicated in the development and maintenance of CLBP (1.1.3.). Various different physiotherapy treatments for CLBP are discussed next, with a focus on prescribed home exercise treatment (1.1.4.). Lastly, the literature review focuses on the effectiveness of exercise programmes in improving outcome for people with CLBP (1.1.5.). In order to demonstrate the importance of investigating adherence to prescribed home exercise in CLBP, it is essential to understand whether or not prescribed home exercise is an effective treatment. To do this, evidence is presented from five reviews that assess the effectiveness of exercise programmes for CLBP.

### 1.1.1. Definition and categorisation of low back pain

Standard definitions of low back pain (LBP) lack consistency, and LBP has proven to be difficult to define due to linguistic, methodological and experimental variability (Dionne et al., 2008; Jordan, Holden, Mason, & Foster,

2010). In physiological terms, back pain can be defined as “pain, muscle tension or stiffness localised below the costal margin and above the inferior gluteal folds, with or without leg pain” (van Middelkoop et al., 2010, p. 194). Low back pain (LBP) can be classified into three categories (Airaksinen et al., 2006; Waddell, 1987). These are specific spinal pathology, nerve root pain / radicular pain and non-specific LBP. This thesis focuses on non-specific CLBP, that is “LBP that is not attributable to a recognisable, known specific pathology (e.g. infection, tumour, osteoporosis, fracture, structural deformity, inflammatory disorder e.g. ankylosing spondylitis, radicular syndrome or cauda equina syndrome)” (Airaksinen et al., 2006). Approximately 90 percent of people with LBP are diagnosed with non-specific LBP (van Middelkoop et al., 2010).

Non-specific LBP is categorised based on duration of pain (Chanda, Alvin, Schnitzer, & Apkarian, 2011; Spitzer & LeBlanc, 1987). Generally accepted categories of LBP are acute (≤ 6 weeks), sub-acute (6 to 12 weeks), and chronic (>12 weeks) (van Middelkoop et al., 2010; NICE, 2009) although some research does not distinguish between acute and sub-acute LBP (NICE, 2009). Additionally, back pain researchers and professional health organisations often specify different durations for chronic pain. For example, categorisations of chronicity differ from as low as 6 weeks or more (NHS, 2013; NICE, 2009), to 12 weeks or more (Scottish Intercollegiate Guidelines Network, 2013; Clinical Standards Advisory Group, 1994), to as high as 6 months or more (Merskey, 1994). Inconsistencies in definition make it problematic to compare results of different studies (Beinart, Goodchild, Weinman, Ayis, & Godfrey, 2013; Dionne et al., 2008). This thesis categorises CLBP as lasting 12 weeks or more.

### 1.1.2. The prevalence and impact of CLBP

LBP can affect people of all ages, from children to the elderly (World Health Organisation, 2003). Additionally, the prevalence of LBP is not related to age (NICE, 2009; Airaksinen et al., 2006). Seventy to 85 percent of people will experience LBP at some point in their lives and between 5 percent and 15 percent of these people will develop CLBP (Liddle et al., 2004). Therefore, between 2.1 million and 7.7 million of the current UK population may develop CLBP at some point in their lives. CLBP is difficult to treat, and 80 percent of people with CLBP are likely to have recurrent symptoms throughout their lives

(Waddell & Schoene, 1998). CLBP has a significant negative impact on people's lives, with deleterious effects on quality of life and both family and social relationships (Fricker, 2003; Arthritis & Musculoskeletal Alliance, 2004). CLBP is known to be a major cause of disability in Western populations and an increasing problem of epidemic proportions (Descarreaux, Normand, Laurencelle, & Dugas, 2002; Deyo et al., 1998).

General population estimates of the prevalence of CLBP in the research literature are varied (Juniper, Le, & Mladsi, 2009). Prevalence rates in the UK range between 6 percent (Croft, Macfarlane, Papageorgiou, Thomas, & Silman, 1998) and 11 percent (Waxman, Tennant, & Helliwell, 2000); between 3.6 million and 6.7 million people. However, more recent research found a higher rate of CLBP (23%) in 2504 adults registered with 16 demographically varied GP practices across England (Parsons et al., 2007). Ninety-eight percent of the UK population are registered with a GP practice in the UK, so if this figure can be extrapolated to the UK population in general, up to14 million people in the UK could be expected to develop CLBP. CLBP is estimated to be the second largest cause of work absence in the UK after common mental disorders (Campbell & Guy, 2007). The most recent estimate of economic loss due to back pain in the UK was £10 billion, with direct healthcare costs of LBP of £1.6 billion (Maniadakis & Gray, 2000). Of the direct healthcare costs, approximately one third related to care provided by physiotherapists and associated specialists and one third was incurred in the hospital sector. The remaining one third was distributed relatively equally amongst primary care, medication, community care, radiology and imaging used for investigation purposes.

### 1.1.3. The development and maintenance of LBP

Traditionally, CLBP has been considered from the perspective of the medical model (Waddell, 1987). The medical model assumes that symptoms, such as pain and disability, are directly attributable to underlying physical pathology and that treatment based on pathology should reduce or cure symptoms (Campbell, 1997). However, conventional medical treatment for CLBP has not proven able to solve the problem, and it is now widely accepted that psychological factors play a key role in the development and maintenance of CLBP (Pincus & McCracken, 2013; Nagarajan & Nair, 2010; Kendall, 1999; Waddell, 1987).

Evidence for the role of psychosocial factors in the development and maintenance of CLBP has been contradictory (e.g. Chou & Shekelle, 2010; Hayden, Dunn, Van der Windt, & Shaw, 2010). However, a recent review by Pincus and McCracken (2013) found strong evidence supporting the role of five psychosocial factors in the development and maintenance of CLBP. These factors are fear-avoidance beliefs (1.1.3.1.), anxiety, depression and pain catastrophizing (1.1.3.2.), and illness perceptions (1.1.3.3.). These five factors are assessed in the present research and are discussed in this chapter. Due to conceptual overlap between some of these psychosocial factors, they are discussed in three, rather than five, sections for the purposes of clarity and to avoid repetition.

#### 1.1.3.1. Fear-avoidance beliefs

The fear-avoidance model posits that individuals with acute or sub-acute LBP, who interpret their pain as threatening, are unlikely to maintain engagement in daily activities that may otherwise help to maintain function (Leeuw et al., 2007; Waddell, Newton, Henderson, Somerville, & Main, 1993). This leads to a cycle of inactivity and avoidance of activities that are believed by the patient to increase pain or cause further injury. Evidence from CLBP research supports the existence of this fear-avoidance cycle (Rainville et al., 2011). For example, a review by Vlaeyen and Linton (2000) found that individuals with CLBP who presented with pain-related fearful beliefs performed less well on physical tasks. Furthermore, pain-related fear beliefs in CLBP have been associated with decreased speed in a walking task (Al-Obaidi, Al-Zoabi, Al-Shuwaie, Al-Zaabie, & Nelson, 2003) and decreased strength in a muscle strength task (Goubert, Crombez, & Lysens, 2005). These studies support the notion that people with high fear-avoidance beliefs in CLBP avoid physical activity in daily life. However, caution should be exercised when generalising results from experimental tasks to daily life. Despite this criticism, a more ecologically valid investigation of causal factors of CLBP found that high levels of pain catastrophizing and high levels of fear-avoidance behaviours prospectively predicted CLBP at 6-month follow-up for individuals with and without LBP at baseline (Picavet, Vlaeyen, & Schouten, 2002). This provides stronger, additional support for the role of psychological factors in the development and maintenance of CLBP.

Evidence shows that fear-avoidance beliefs consistently predict poor outcome in CLBP (Pincus & McCracken, 2013; Rainville et al., 2011). However, conceptualisation of fear-avoidance beliefs varies across studies. One reason for this is due to different questionnaires assessing different components of fear-avoidance (e.g. beliefs and/or behaviours and exercise and/or daily activities). This leads to lack of clarity in defining what aspects of fear-avoidance are most able to predict the development and maintenance of CLBP. A more comprehensive conceptualisation of fear-avoidance beliefs has been suggested as necessary to improve the depth of our understanding thus far (Pincus & McCracken, 2013).

#### 1.1.3.2. Anxiety, depression and pain catastrophizing

A great deal of CLBP research assesses both anxiety and depression, or anxiety and pain catastrophizing, due to considerable conceptual overlap between these three factors (Pincus & McCracken, 2013). Therefore, these three psychological factors are presented together here.

A systematic review by Pincus and colleagues (2002) found that depression and anxiety predicted whether an individual with LBP might develop CLBP. They did not find fear-avoidance and pain catastrophizing to have any predictive value. However, only one study assessing these factors met the inclusion criteria (Klenerman et al., 1995). Recent evidence has further supported the role of anxiety and depression in the development and maintenance of CLBP, in addition to pain catastrophizing (e.g. Kroenke et al., 2013; Sagheer, Khan, & Sharif, 2013; Tangestani, 2012; Thomas et al., 2010). A large proportion of people with CLBP have been reported to have symptoms of anxiety (63%; Tangestani, 2012), depression (51%; Sagheer et al., 2013) and pain catastrophizing beliefs (78%; Tangestani, 2012). Furthermore, women were significantly more likely to report anxiety and depression (Sagheer et al., 2013) or anxiety and pain catastrophizing (Tangestani, 2012) than men. Being affected by one or more of these co-morbid psychological issues increases levels of disability and pain, and predicts both the development (e.g. Picavet et al., 2002) and maintenance (e.g. Smeets, Vlaeyen, Kester, & Knottnerus, 2006; Peters, Vlaeyen, & Weber, 2005) of CLBP.

Co-morbid anxiety, depression and pain catastrophizing have been shown to influence and predict CLBP. However, due to conceptual overlap between these psychological factors, it is difficult to understand which components of each factor influence CLBP (Thomas et al., 2010; Pincus & McCracken, 2013). For this reason, it is important that a range of psychological factors be assessed in CLBP research (Pincus & McCracken, 2013).

#### 1.1.3.3. Illness perceptions

Illness perceptions are derived from Leventhal and colleagues' (1984) common-sense model of self-regulation of health and illness. They are defined as cognitive representations of a person's own illness (Broadbent, Petrie, Main, & Weinman, 2006). There are five illness representations that relate to individuals' beliefs and expectations about their illness and treatment: a) identity (i.e. symptoms experienced); b) consequence (i.e. possible impact of the illness on one's life); c) cause (i.e. beliefs about causality); d) timeline (i.e. how long the illness is expected to last); and e) control/cure (i.e. the extent to which the illness is perceived to be controllable or curable through treatment or this person's own behaviour).

Specific illness perceptions have been shown to predict high disability and inactivity in LBP, thus influencing the development and maintenance of CLBP. Foster and colleagues (2008) found that people who expected their CLBP to have a long duration (timeline), who perceived serious consequences (consequence) and who felt that they did not have control over their back pain (control/cure) had higher disability scores 6 months after initial testing. More recently, Foster and colleagues (2010) found similar results with a different mixed LBP and CLBP sample. However, illness identity, rather than consequence, was found to predict maintenance of disability in CLBP. Furthermore, a recent study found that an intervention targeting illness perceptions improved physical activities relevant to patients' CLBP treatment (Siemonsma et al., 2013). In line with the results of Foster and colleagues (2008), maladaptive illness perceptions regarding consequence and personal control affected their CLBP sample. These two illness perceptions predicted improvement in physical activity in Siemonsma and colleagues' (2013) study.

This, in turn, assisted in breaking the cycle of activity avoidance that has been shown to maintain CLBP (Rainville et al., 2011).

Preliminary research suggests that illness perceptions play a role in the development and maintenance of CLBP. However, the two studies by Foster and colleagues (2008; 2010) included mixed samples with acute, sub-acute and CLBP. It was not possible to extract information regarding the percentage of each sample with CLBP due to differences in characterisation of duration of LBP in both studies. For example, duration of LBP consisted of three categories in the 2010 study (<1 month, 1-7 months and >7 months). Whereas, the 2008 study described duration of pain in relation to current episode of pain. This leads to difficulties generalising from the findings of these two studies to a CLBP population. In addition to this, Siemonsma and colleagues' (2013) and Foster and colleagues' (2008) studies found the same illness perceptions predicted exercise behaviour. Siemonsma and colleagues' (2013) sample consisted entirely of individuals with CLBP. However, Foster and colleagues' (2008; 2010) studies used the Revised Illness Perceptions Questionnaire to assess illness perceptions. Whereas, Siemonsma and colleagues (2013) used Socratic dialogue to identify maladaptive illness perceptions as part of a CBT intervention. Therefore, it is problematic to compare findings across studies. Nevertheless, the studies described in this section provide initial evidence of relationships between illness perceptions and disability in LBP and CLBP (Foster et al., 2010; 2008) and physical activity in CLBP (Siemonsma et al., 2013).

Research findings have confirmed the role of fear-avoidance, anxiety, depression, pain catastrophizing and illness perceptions in the development and maintenance of CLBP (Pincus & McCracken, 2013). However, conceptual overlap between these five factors has led to difficulties distinguishing which aspects of psychological functioning influence or predict CLBP (Pincus & McCracken, 2013). For example, there appears to be a general, negative affect component underlying the five psychological factors. Therefore, any measure that assesses negative affect may produce similar findings, without identifying which specific psychological components are responsible for the results. This limitation has been noted by Campbell and colleagues (2013), who investigated the conceptual overlap of psychological constructs used in LBP research. They

found pain-related emotional distress to be a predominant common component of all psychological measures assessed. Prospective investigation of psychological factors that influence pain-related distress will provide information that may help better predict the development and maintenance of CLBP. This would allow for earlier intervention that may reduce the likelihood of an individual developing CLBP or provide more effective treatments for those with prolonged CLBP.

### 1.1.4. Treatment of CLBP

In spite of the controversies surrounding defining, categorising and the development and maintenance of CLBP, detailed and evidence-based guidance on treatment for LBP has been developed (e.g. NICE, 2009). The current section gives a brief overview of the different treatment options available to an individual with CLBP attending a physiotherapy service in the UK. NICE (2009) guidelines are presented as the main guidance for physiotherapy treatment of CLBP in the UK (1.1.4.1). Then, there is a brief discussion of recent advances in clinical assessment that have been shown to successfully improve short-term clinical outcome for individuals with CLBP (1.1.4.2.).

The UK-based Chartered Society of Physiotherapy (CSP) promotes the use of NICE clinical guidelines to inform the clinical decision making of their professional members in the UK. However, NICE does not provide guidance for CLBP of 12 months and over.[1] Therefore, guidance from the Arthritis and Musculoskeletal Alliance (ARMA, 2004), recognised by the CSP as an additional important resource, was considered here as a source of treatment recommendations for CLBP of 12 months or more. ARMA's (2004) and NICE's (2009) guidance were compared and treatment recommendations for CLBP of less than 12 months and CLBP of more than 12 months were found to be almost identical. Furthermore, ARMA refer to NICE (2001) for detailed recommendations about treatment of CLBP. Moreover, although NICE (2009) state that its guidance relates only to CLBP of 6 weeks to 12 months, guidance

[1] Topics are referred to NICE by the Department of Health, NHS England and other Government departments in line with established national priorities that they have established, and NICE have not yet been asked to produce guidance on the topic of back pain with a duration of 12 months and over (Carla Springl, Communications Coordinator for NICE; personal email communication, January 9th, 2015).

referring to shorter-term CLBP tend to be followed for CLBP with a duration of 12 months or longer where specific guidance is unavailable (Slade, Molloy, & Keating, 2012).

#### 1.1.4.1. Guidance for treatment of CLBP

NICE (2009) guidelines highlight the importance of maintenance of general exercise and having a physically active lifestyle. With regards to exercise as a treatment for CLBP, NICE (2009) guidance recommends that treatment is based on the biopsychosocial model of illness where biological, psychological and social factors are posited to play a role in explaining the development and maintenance of CLBP. It is necessary to differentiate between general exercise and physical activity and therapeutic exercise used for rehabilitation purposes in the treatment of CLBP. General exercise and physical activity refer to the long-term maintenance of a physically active lifestyle to manage a CLBP condition. By contrast, therapeutic exercise refers to exercises performed in-clinic (in a supervised group or one-to-one setting) or prescribed home exercises performed outside the clinic to assist the long-term self-management of CLBP. The focus of this thesis is to further understand the role of prescribed home exercise in the management of CLBP. Thus, the term ‘prescribed home exercise’ is used throughout the thesis when discussion focuses on this type of exercise programme. Examples of NICE (2009) treatment recommendations for CLBP are listed in Table 1.

**Table 1.** ***NICE (2009) recommendations for the treatment of CLBP***

| NICE Recommendations | Description |
|---|---|
| Information, education and patient preferences | Offer one of three treatments (exercise, manual therapy or acupuncture), whilst accounting for patient expectations and preferences. |
| Physical activity and exercises | Offer one of three programmes (individually-tailored structured exercise, group exercise or one-to-one supervised exercise). |
| Manual therapy | Offer a course of manual therapy (including spinal manipulation). |
| Other non-pharmacological therapies | Electrotherapy modalities; for example, ultrasound or pulsed shortwave therapy. |
| Invasive procedures | Acupuncture needling. |
| Combined physical and psychological treatment | This should include cognitive behavioural approaches and exercise for people with high disability and psychological distress or both. |
| Pharmacological therapies | Recommend regular paracetamol, and if this is insufficient, offer non-steroidal anti-inflammatories and weak opioids or both. If insufficient, suggest short-term use of strong opioids or tricyclic anti-depressant medication. |
| Referral for surgery | Consider spinal fusion surgery only when previous treatments are insufficient. |

With regards to therapeutic exercise, research evidence suggests that exercise programmes are moderately effective at reducing pain and disability in patients with CLBP (van Middelkoop et al., 2010; Hayden, van Tulder, Malmivaara, & Koes, 2005). The most effective approach when treating CLBP has been shown to be individually-tailored exercise programmes delivered in a one-to-one supervised format (e.g. home exercise with regular one-to-one in-clinic follow-up; Hayden et al., 2005). NICE (2009) guidelines follow Hayden and colleagues' (2005) recommendations to provide individually-tailored exercise programmes delivered in a one-to-one supervised format for people with CLBP. However, when one-to-one in-clinic exercise programmes have been compared with group exercise programmes for the treatment of CLBP, group exercise programmes have been found to be more cost-effective (NICE, 2009) and equally as effective at reducing pain level and frequency (Mannion et al., 2001). Based on this evidence, NICE (2009) suggests supervised group exercise programmes for the treatment of most people with CLBP. In cases where group exercises may not be suitable, one-to-one in-clinic exercise programmes are recommended.

For people with CLBP who do not respond favourably to initial treatment and have high disability and/or distress, combined physical and psychological treatment as part of a biopsychosocial approach is recommended (NICE, 2009). A treatment programme is suggested to include approximately 100 hours over a period of 8 weeks. The programme should include a cognitive-behavioural approach and include an exercise component. NICE (2009) guidance discusses 11 randomised controlled trials (RCTs) that provide evidence for the effectiveness of combined physical and psychological treatment. However, only two of the 11 trials were found to be well-conducted RCTs with a low risk of bias (Kääpä, Frantsi, Sarna, & Malmivaara, 2006; Smeets et al., 2008). Kääpä and colleagues (2006) compared combined CBT with individual physical therapy for CLBP. Smeets and colleagues (2008) compared combined therapy to individual psychological therapy (not labelled as CBT) or individual physical therapy. Both RCTs found no effect of the psychological/CBT programme on pain or disability at 12 months (Smeets et al., 2008) or 24 months (Kääpä et al., 2006). Therefore, NICE guidance appears to be based on the results of the remaining nine RCTs that were found to have a high risk of bias. Two of the remaining

nine trials also found no differences between combined psychological and physical therapy and a control group having physiotherapy or no treatment (Bendix et al., 1995; Critchley, Ratcliffe, Noonan, Jones, & Hurley, 2007). Overall, four RCTs found no benefit of combined treatment, and the seven RCTs that reported a significant effect on outcome (e.g. pain and disability) all had a high risk of bias. Therefore, although NICE (2009) recommends combined treatment for CLBP, more evidence is required in order to further understand the effectiveness of combined treatment on outcome.

Since the reporting of NICE guidelines (2009), a systematic review and meta-analysis found that the biopsychosocial approach to treating CLBP (i.e. physical therapy plus a psychological and social component) has led to improved clinical outcome (i.e. lower pain and disability) compared to traditional physiotherapy (Kamper et al., 2015). This systematic review included seven of the nine RCTs included in the NICE (2009) guidance. The two RCTs that were not included in Kamper and colleagues' (2015) systematic review did not meet inclusion criteria for the review. One excluded trial included a mixed acute, sub-acute and CLBP sample (Corey, Koepfler, Etlin, & Day, 1996). The second excluded trial (Critchley et al., 2007) did not include combined psychological and physical therapy treatment, which was the focus of the Kamper and colleagues' (2015) review. However, Critchley and colleagues' (2007) trial should also not have been included in the NICE (2009) guidance regarding combined interventions for the same reason.

Kamper and colleagues' (2015) review did not include a large LBP trial (*n*=701) that compared an active management control group (i.e. encouragement to maintain physical activity plus written information to challenge negative beliefs and behaviours) with an active management plus CBT intervention group (BeST trial; Lamb et al., 2010). One reason for exclusion of this trial in Kamper and colleagues' (2015) review may be because the BeST trial included a mixed sub-acute and CLBP sample. However, sub-group analysis divided duration of pain into two groups (6 weeks to 3 years and > 3 years). Therefore, findings relevant to CLBP were provided by the BeST trial. Lamb and colleagues (2010) found no significant differences in clinical outcome between the two groups in individuals with LBP and CLBP.

The BeST trial is one example of a trial that appeared to satisfy inclusion criteria for Kamper and colleagues' (2015) systematic review, but was not included. As is the case with any systematic review, relevant trials may not be located for a number of reasons (e.g. pre-conceived notions of the authors of the original research studies, as well as the authors of the systematic reviews; Garg, Hackam, & Tonelli, 2008). Nonetheless, Kamper and colleagues' (2015) review benefitted from an absence of language constraints and the use of gold standard guidelines for conducting systematic reviews and meta-analyses (Higgins & Green, 2008). Their findings demonstrate the benefits of treatment for CLBP using a multidisciplinary biopsychosocial approach over traditional physiotherapy treatment. Kamper and colleagues' (2015) review provides current information regarding effective long-term (over 12 months) treatment for CLBP where conventional physiotherapy treatments are seldom effective after 3 months (Traeger et al., 2014).

The use of the biopsychosocial model in practice comes with an expectation that physiotherapists can assess and treat a multitude of interacting factors with limited psychosocial training and within certain time restrictions. This expectation has been met with qualitative research concluding that some physiotherapists feel under-prepared for the challenges of supporting individuals with chronic conditions (Slade et al., 2012). Furthermore, Slade and colleagues (2012) found that physiotherapists had a tendency to default to treatment recommendations for short-term CLBP (i.e. less than 12 months) due to lack of guidance specifically for the treatment of CLBP. Thus, although the biopsychosocial approach has resulted in substantial improvements in the treatment of CLBP (Kamper et al., 2015), lack of clear guidance leads to difficulties when participating in shared decision-making with the CLBP patient (Slade et al., 2012).

#### 1.1.4.2. Sub-grouping LBP

CLBP is a long-term condition that is difficult to treat. One reason for this may be because many treatments (e.g. combined psychological and physical therapy) have a mixed, or inadequate, evidence base (NICE, 2009). Recent advances in clinical assessment have found a way to overcome difficulties selecting treatment options for individuals with CLBP with the introduction of the

Keele 9-item STarT back screening tool (SBST) and the Keele SBST clinical measurement tool (Hill et al., 2011; 2008). The SBST provides information that allows physiotherapists to stratify LBP patients based on risk factors including disability, distress, pain and catastrophizing. Resulting scores stratify patients into low-, medium- and high-risk categories, with associated treatment plans. This stratified approach has been found to reduce disability in high-risk LBP patients compared to conventional physiotherapy treatment over a 4-month period (Hill et al., 2011). The SBST recommends that high-risk patients be treated using a combined physical and cognitive-behavioural approach. However, the Hill and colleagues (2011) study found that reductions in disability were not significant at 12 months. Recent chronic pain research suggests that a key reason for this may be because the effectiveness of cognitive-behavioural treatments has reached a plateau (Eccleston et al., 2013).

Eccleston and colleagues (2013) reviewed psychological approaches for chronic pain management and found that effect sizes for outcomes (i.e. depression, disability and pain) ranged from small to medium. The authors argued that these effects sizes cannot provide information regarding the responses of individual patients to specific treatments, leading to the aforementioned plateau. In order to improve treatment effectiveness, Eccleston and colleagues (2013) suggested that future research uses less heterogeneous samples in order to better understand the responses of individual patients for specific treatments. In addition to this, it has been suggested that new information regarding factors influencing the maintenance of CLBP is needed to further our understanding of the problem and enable more effective long-term treatment (Farmer, Baliki & Apkarian, 2012). One aim of the present research is to investigate novel factors (i.e. executive functions) that may influence the maintenance of CLBP and its subsequent treatment.

### 1.1.5. Effectiveness of exercise treatment for CLBP

Prescribed home exercise is a key component of physiotherapy treatment for CLBP (NICE, 2009). For this reason, it is important to understand the effectiveness of prescribed home exercise programmes for CLBP. Systematic reviews assessing the effectiveness of exercise programmes are discussed in the current section. However, all reviews in this area assess a variety of

exercise programmes. There are no reviews that assess the effectiveness of home exercise programmes alone. There are two systematic reviews assessing the effectiveness of exercise therapy where data for CLBP samples are analysed independently of acute and sub-acute LBP data (Hayden et al., 2005; van Tulder, Malmivaara, Esmail, & Koes, 2000). There are three further reviews with a sole focus on the effectiveness of exercise therapy for CLBP (van Middelkoop et al., 2010; Liddle et al., 2004; Hilde & Bø, 1998).

An early review by Hilde and Bø (1998) included two out of nine studies that focused on home exercise as part of an exercise programme. However, the researchers were unable to draw firm conclusions about the effectiveness of exercise programmes for reducing pain and disability for CLBP. A later review by Liddle and colleagues (2004) found that despite the variety of exercise programmes prescribed for CLBP, exercise resulted in positive outcomes for all of the 16 included RCTs. Exercise programmes were effective at reducing disability, pain, and work-related disability, and improving general health status and satisfaction with treatment (Liddle et al., 2004). Five of the 16 studies incorporated a home exercise component (defined as 'partially supervised' or 'unsupervised' in the review), and the other 7 studies were unclear (defined as 'fully supervised'). Hayden and colleagues (2005) published a meta-analysis of the effectiveness of exercise programmes for acute, sub-acute and CLBP. Twenty of the 43 studies that investigated CLBP incorporated home exercise as part of the treatment. They concluded that prescribed exercise programmes are moderately effective at improving pain and function for individuals with CLBP. A more recent review by van Middlekoop and colleagues (2010) reported the same conclusions as Hayden and colleagues (2005), providing further evidence for the effectiveness of exercise programmes in the treatment of CLBP.

The five reviews discussed here included multiple exercise treatments for CLBP (e.g. muscle strengthening, flexibility training, aerobic exercise, McKenzie exercises, Williams Flexion exercises, ergonomic advice and multimodal exercise treatments). The reviews focused on a range of exercise treatment modalities (e.g. home exercise with supervised follow-up and unsupervised prescribed home exercise). In addition, different types of participants were investigated within each review (i.e. different occupational groups and different age ranges). For these reasons, it is difficult to generalise the conclusions of

these reviews solely to the effectiveness of prescribed home exercise programmes in a CLBP sample comprising of a range of occupations and ages. However, with the exception of the results of Hilde and Bø's (1998) review, it can be concluded that exercise programmes appear effective at improving clinical outcome for people with CLBP. However, there is disagreement about the strength of this evidence (van Middelkoop et al., 2010). For example, all of the reviews commented on the low quality and high risk of bias of many included studies. RCTs investigating the effectiveness of separate exercise modalities, with long-term follow-up, are required in order for clearer conclusions to be drawn about the effectiveness of prescribed home exercise programmes for CLBP.

### 1.1.6. Summary of Section 1.1: The problem of CLBP

Section 1.1 has introduced the issue of CLBP and its substantial impact on the individual, the NHS and society. Evidently, CLBP remains a costly and challenging problem for the individual, the NHS, and society at large (NICE, 2009). For these reasons, CLBP is an important area to research. However, CLBP is a complex area of study due to a lack of consensus among pain researchers and healthcare organisations regarding how to define the condition. In addition, it is unclear what factors affect the development and maintenance of CLBP (Chanda et al., 2011). There is no universally agreed best practice when selecting a treatment for CLBP (NICE, 2009). Current physiotherapy treatments for CLBP were discussed in this section. However, the fact that no single exercise programme has been found to be most effective for the treatment of CLBP has added to the complexities of developing effective treatments for patients. The treatment of sub-groups of individuals with CLBP using the SBST demonstrated short-term improvement in clinical outcome (Hill et al., 2011). However, improvements were not significant at long-term follow-up. Finally, exercise programmes in general were found to be effective at improving outcome for individuals with CLBP. Home exercise programmes are designed to encourage patients to remain active post-treatment and long-term adherence to these programmes is important for patients to maintain lasting benefits (Friedrich, Gittler, Arendasy, & Friedrich, 2005). However, many individuals with CLBP do not adhere to prescribed home exercises. Discussion of exercise

adherence behaviour in the next section provides information that forms a basis for further study of prescribed home exercise in CLBP.

## 1.2. Non-adherence to home exercise

This section discusses definitions of exercise adherence behaviour and existing data regarding the prevalence of non-adherence to prescribed home exercise in CLBP (1.2.1.). Next, interpretation of exercise adherence behaviour is discussed in relation to interpretations used in medication adherence research literature (1.2.2.). This sub-section discusses the use of cut-off scores in medication and exercise adherence research literature. Consequently, a continuum is suggested to be a more appropriate scale on which to measure exercise adherence behaviour. Next, adherence behaviour is discussed based on the categories of intentional and unintentional behaviours. Subsequent to this, difficulties assessing exercise adherence behaviour are discussed with a focus on the lack of valid and reliable measures in the CLBP research literature (1.2.3.). Finally, the current section is briefly summarised (1.2.4.).

### 1.2.1. Definition and prevalence of adherence behaviour in CLBP

Researchers do not agree about how to define adherence behaviour, which has led to inconsistencies in research findings regarding non-adherence to prescribed home exercise in CLBP. Examples of terms used in adherence research literature are described in this section. However, varying definitions used throughout exercise adherence research lead to difficulties understanding the full extent of non-adherence to back pain exercises. Nonetheless, available prevalence data regarding home exercise adherence behaviour in CLBP is provided in this section.

Many terms have been used to describe adherence to treatment in medication and exercise research literature, including ‘co-operation’, ‘compliance’, ‘engagement’, ‘partnership’, ‘concordance’ and ‘adherence’ (Jordan et al., 2010). In this thesis, the term ‘adherence’ is used when referring to performance of prescribed home exercises. This is because performance of prescribed home exercises requires active voluntary participation by the patient in order to self-manage their condition (Meichenbaum & Turk, 1987). Whereas, a term such as ‘compliance’ implies a lack of patient involvement (Bassett,

2003). A general definition of adherence behaviour that has been used throughout exercise adherence literature is ‘the extent to which a person’s behaviour [....] corresponds with agreed recommendations from a healthcare provider’ (World Health Organisation, 2003).

Prevalence data relating to non-adherence to prescribed exercise in CLBP is lacking. One reason for this is that adherence is seldom assessed in research investigating the effectiveness of exercise programmes (Beinart et al., 2013; Mannion, Helbling, Pulkovski, & Sprott, 2009). When adherence has been assessed, exercise researchers have generally investigated different types of adherence (e.g. adherence to appointment attendance, in-clinic advice, or prescribed home exercise; McLean, Burton, Bradley, & Littlewood, 2010; Jack, McLean, Moffett, & Gardiner, 2010; Jordan et al., 2010; Mannion et al., 2009). These three types of adherence are not usually separated for the purposes of evaluation, providing lack of clarity when drawing conclusion from this research. Prevalence data are therefore presented from the few studies that have only assessed adherence to prescribed home exercise in CLBP. CLBP research literature has found non-adherence to be between 50 percent (Friedrich, Gittler, Halberstadt, Cermak, & Heiller, 1998) and 70 percent (Harkapaa et al., 1991; Reilly et al., 1989). These studies are discussed in detail in the systematic review conducted for Study 1 of the present research (Chapter 3).

### 1.2.2. Categorisations of adherence behaviour

Medication adherence research has provided a basis for the conceptualisation of exercise adherence behaviour on two levels: a) interpretation of adherence behaviour as a dichotomy or a continuum; and b) reasons for non-adherence based on intentional and unintentional behaviours. This section discusses conceptualisation of exercise adherence behaviour as a dichotomy or a continuum (1.2.2.1.). Subsequent to this, discussion focuses on intentional and unintentional non-medication adherence behaviour in order to provide some understanding of conceptualisations of adherence behaviour in the present research (1.2.2.2.).

#### 1.2.2.1. Exercise adherence behaviour as a dichotomy and a continuum

The medication adherence research literature has often used cut-off scores to categorise adherence behaviour as a dichotomy (e.g. Sjölander, Eriksson, & Glader, 2013; Glombiewski, Nestoriuc, Rief, Glaesmer, & Braehler, 2012). However, data are available in the research literature regarding the level of medication required to achieve an effective result. For example, 95 percent adherence to protease inhibitor therapy is required for patients with HIV to experience successful virologic and immunologic outcome (Machtinger & Bangsberg, 2007). Therefore, the use of cut-off scores in medication adherence research can provide important information about which individuals are most at risk of poor outcome.

In CLBP research, cut-off scores have been used to describe adherent and non-adherent exercise behaviour for interventions investigating adherence to prescribed home exercise (e.g. Hayden et al., 2005). Researchers may have deferred to the practice of using cut-off scores due to lack of information regarding the necessary level of adherence required for exercise to improve clinical outcome. However, it is yet unknown what level of adherence to prescribed home exercise is necessary for improved clinical outcome. Thus, cut-off scores appear to provide arbitrary dichotomies that place patients into groups based on supposedly adherent and non-adherent behaviours. For the reasons stated in this section, it is believed that assessing exercise adherence behaviour on a continuum may provide a broader and more realistic understanding of adherence behaviour (McHorney, 2008; Jackson, Eliasson, Barber, & Weinman, 2014).

#### 1.2.2.2. Intentional and unintentional non-adherence behaviours

Exercise adherence behaviour is rarely categorised as intentional or unintentional. However, adherence behaviours have frequently been described as intentional and unintentional in the medication adherence research literature (Lehane & McCarthy, 2007). Studies investigating adherence to medication have shown that non-adherence can be the result of both intentional and unintentional behaviours (e.g. Mukhtar, Weinman, & Jackson, 2014; Brady & Weinman, 2013; Lehane & McCarthy, 2007). Intentional non-adherence relates to patients' beliefs and motivation to persist with treatment, whereas

unintentional non-adherence is understood in terms of skills and abilities (Horne et al., 2005). For example, an intentionally non-adherent patient may choose not to follow treatment advice because they believe that the cost of the side-effects are not worth the benefits of taking their medication (i.e. an active process) (Horne et al., 2013). Conversely, an unintentionally non-adherent patient may forget or be unable to follow treatment advice (i.e. a passive process). For example, they may have health literacy issues and not fully understand written instructions. Past medication adherence research has argued for the importance of assessing intentional and unintentional non-adherence behaviour as separate entities (e.g. Wroe, 2002). However, intentional and unintentional non-adherence are now believed not to be as separable as previously thought (Gadkari & McHorney, 2012).

Unintentional non-adherence has traditionally been believed to be a random, passive process and, therefore, difficult to change (Ho, Bryson, & Rumsfeld, 2009). However, medication adherence research has found that factors commonly associated with intentional non-adherence predicted unintentional non-adherence (Gadkari & McHorney, 2012). For example, forgetting is an unintentional behaviour that is influenced by intentional factors regarding beliefs about medication. Furthermore, recent research investigating intentional non-adherence in older adults found evidence of overlap between the two types of medication adherence behaviour (Mukhtar et al., 2014; McHorney & Spain, 2011, cited in Jackson et al., 2014). Findings of extensive overlap between the categories of intentional and unintentional non-adherence has led to the suggestion that these categories are no longer of use when intervening to improve medication adherence behaviour (Jackson et al., 2014). Moreover, it has been argued that this conceptualisation of adherence behaviour does not account for unconscious mental processes that have been associated with health behaviour decisions (Lehane & McCarthy, 2007). For the reasons mentioned in the current section, exercise non-adherence may not be usefully categorised as intentional or unintentional.

### 1.2.3. Difficulties measuring exercise adherence behaviour

There is currently no valid and reliable tool for measuring exercise adherence behaviour in CLBP (Bollen, Dean, Siegert, Howe, & Goodwin, 2014; Jordan et

al., 2010; McLean et al., 2010). This section discusses possible methods of assessing adherence to prescribed home exercise in CLBP that were considered when planning the present research. Methods of assessment of adherence behaviour are discussed in relation to subjective and objective methods. Subjective methods include self-report measures (e.g. diaries or questionnaires). Objective methods include electronic activity devices (e.g. pedometers and accelerometers) and objective changes in physical movement (e.g. range of motion).

Recent systematic reviews investigating adherence behaviour have found self-report diaries to be the most commonly-used method to assess adherence to exercise in individuals with chronic MSK disorders (including CLBP; Hall & Fong, 2015), mixed MSK disorders (i.e. acute, sub-acute and chronic; Jack et al., 2010) and CLBP (Beinart et al., 2013). A further systematic review found that diaries were used as often as questionnaires to assess adherence to prescribed home exercise for individuals with long-term conditions (including CLBP; Bollen et al., 2014). However, there is no standardised diary method that has been used across research studies, meaning results are not easily comparable. In addition, poor completion rates for diaries, together with inaccurate recall and self-presentation bias, may further affect the validity of diary data (Stone, Shiffman, Schwartz, Broderick, & Hufford, 2003).

Objective, electronic devices have been suggested as more accurate and reliable than diaries for assessing exercise adherence behaviour (Trost, McIver, & Pate, 2005; Bassett, 2003). However, studies assessing exercise adherence behaviour in MSK samples have rarely used objective devices or methods of triangulation (Jordan et al., 2010). A main reason for this may be because objective electronic devices are not always appropriate for assessing the types of exercises prescribed for home exercise programmes (Bollen et al., 2014). This is because electronic devices primarily measure activities of daily living, such as, cleaning, gardening or walking (Yang & Hsu, 2010). In addition, even where prescribed exercises may be suitable for assessment using objective measures (e.g. a pedometer to measure step-count), limitations of objective measures would need to be acknowledged. For example, not all pedometers have been shown to accurately assess step count (Schneider, Crouter, Lukajic, & Bassett, 2003). Frequent measurement of adherence behaviour using

electronic devices may be classed as an intervention in itself, leading to unrealistic data about the true nature of exercise adherence behaviour in a sample (McLean et al., 2010). Moreover, objective measurement devices are most likely to be worn by more adherent individuals, resulting in a smaller range of adherence data than is representative of the larger population (Yuen et al., 2013).

A second objective method of adherence assessment involves assessment by specially trained physiotherapists, in some cases with specialised equipment. This may include repeated methods to assess improvement in range of motion (e.g. measurement of joint angles) and back muscle endurance (e.g. the Biering-Sorensen test). Commercially available equipment has been found to be highly reliable (i.e. inter-observer reliability) for the assessment of lumbar range of motion (Roussel et al., 2008). However, daily variations in muscle function may lead to difficulties obtaining a true measurement when testing occurs irregularly. Furthermore, reduction in self-reported disability after exercise therapy has been found to have little relationship with changes in mobility and back muscle endurance (Steiger, Wirth, De Bruin, & Mannion, 2012). Therefore, this type of assessment may not be appropriate for the assessment of adherence to prescribed home exercise.

There are limitations to both subjective and objective assessment of exercise adherence behaviour. The assessment of adherence behaviour using triangulation of adherence measures has been proposed to increase reliability of findings compared with using a single method of measurement (World Health Organisation, 2003; Tenenbaum & Eklund, 2012). However, for the aforementioned reasons, objective measurement of exercise adherence behaviour in the present research was not feasible. Therefore, triangulation was attempted using subjective measures. However, the lack of standardised measures of exercise adherence behaviour leads to difficulties in reliably measuring adherence to prescribed home exercise. There is a need for valid and reliable measures of exercise adherence to be developed for use in future studies investigating prescribed exercise (Bollen et al., 2014; Beinart et al., 2013; Jordan et al., 2010). Use of a validated measure of adherence behaviour would add robustness to findings in a field of research where reliability of current results is hindered by lack of a standardised measurement tool.

Furthermore, the use of a standardised measure of adherence behaviour should provide consistent information that may be used to inform the intervention and treatment of CLBP in the long-term.

### 1.2.4. Summary of Section 1.2: Non-adherence to home exercise

Section 1.2 has explained inconsistencies regarding definitions of adherence behaviour, together with information regarding the lack of research investigating non-adherence to prescribed home exercise in CLBP. Past medication adherence research literature has provided a basis for the interpretation and categorisation of exercise adherence behaviour. However, lack of evidence regarding level of exercise required to improve clinical outcome in CLBP indicates that useful information would be provided by interpretation of exercise adherence behaviour scored on a continuum. Furthermore, conceptual overlap between the categories of intentional and unintentional non-adherence indicates that these may not be useful categorisations of exercise adherence behaviour. The lack of a standardised measure to assess adherence to prescribed home exercise in CLBP has led to difficulties obtaining accurate information regarding adherence behaviour from the current CLBP research literature. This thesis aims to add to the growing body of CLBP and adherence behaviour research by providing a better understanding of factors associated with prescribed home exercise in CLBP.

## 1.3. Models of behaviour change

This section focuses on discussion of models of behaviour change that have been used to explain and predict exercise behaviour. Firstly, discussion focuses on traditional health behaviour models that have been the focus of much exercise behaviour research literature (1.3.1.). The concept of self-regulation is then introduced as one explanation of why individuals with CLBP may be non-adherent to prescribed home exercise (1.3.2.). A model incorporating self-regulation is considered as a theoretical basis for the present research investigating exercise adherence behaviour in CLBP: Temporal Self-regulation Theory (TST) (Hall & Fong, 2007) (1.3.3.). Lastly, the current discussion regarding models of behaviour change is summarised (1.3.4.).

### 1.3.1. Traditional theories and models of behaviour change

Traditional health behaviour models have been used as a theoretical basis for understanding and predicting engagement in exercise behaviour. Health behaviour models that have been applied to exercise behaviour include the theory of reasoned action (Fishbein & Ajzen, 1975), the theory of planned behaviour (TPB) (Ajzen, 1991), the health belief model (Rosenstock, 1974), self-efficacy theory (Bandura, 1977), protection motivation theory (Maddux & Rogers, 1983), the health action process model (Schwartzer, 1992), and the transtheoretical model (TTM) (Procheska & Diclemante, 1983). Health behaviour models that are best known for their roles in investigations of exercise behaviour are the TPB and TTM (Hall & Fong, 2015). Therefore, these two models are discussed in this section. The TTM is briefly described. However, the main focus is on the TPB, as this is the basis upon which a recent model of behaviour change relevant to the present research has been founded (temporal self-regulation theory, Hall & Fong, 2007).

Procheska and DiClemente's (1983) TTM assumes that people go through five stages of change that explain their readiness to engage in regular exercise behaviour. These are pre-contemplation, contemplation, preparation, action and maintenance. When people are non-adherent (i.e. relapse), they can move backwards and forwards through the stages until they ideally reach the maintenance stage. The TTM states two key components necessary for successful behaviour change. These are self-efficacy (i.e. the belief that one has mastery over one's actions) and decisional balance (i.e. weighing the costs and benefits of changing behaviour). Marshall and Biddle (2001) did a meta-analysis of research investigating exercise behaviour using the TTM. The meta-analysis included 91 studies and found that most behaviour change was in the direction predicted by the TTM. However, many studies in this meta-analysis were cross-sectional and did not examine moderators and mediators of each stage of change. A later critical review found that stage-based exercise behaviour interventions were effective in the short term (<6 months), but not in the long term (>6 months) (Adams & White, 2005). According to the review, the TTM has only received modest support for its ability to predict exercise behaviour. Furthermore, lack of longitudinal research has led to difficulties

surmising conclusively regarding the long-term effects of TTM-based interventions.

The TTM has been criticised for being unable to explain the actual process of behaviour change (Middleton, 2004). Furthermore, it has been argued that many interventions utilising the TTM do not adequately define the five stages of change, perhaps accounting for the lack of effectiveness of some TTM interventions (Taylor et al., 2006). In addition to this, the TTM has been suggested to be more effective for changing individual behaviours (e.g. smoking) than exercise behaviour, which may include multiple behaviours (Adams & White, 2005). Moreover, the TTM attempts to explain exercise behaviour change in stages, when exercise behaviour is claimed to be better assessed on a continuum (Jackson et al., 2014; Taylor et al., 2006).

The TPB has frequently been used to explain exercise behaviour (e.g. Kumar, 2012; Chatzisarantis & Hagger, 2005; Rhodes, Courneya, & Jones, 2003; Norman, Conner, & Bell, 2000; Armitage & Conner, 2000). The TPB states that three factors predict behaviour: a) attitude (positive or negative evaluation towards performing a behaviour); b) subjective norm (social expectation of performing a behaviour); and c) perceived behavioural control (PBC) (belief that one has control over their behaviour). The TPB predicts behaviours that require deliberate (i.e. conscious) planning in relation to a goal, prior to initiation of the behaviour (Ajzen, 1991). Exercise behaviour requires planning and goal-setting, thus the TPB is argued to be directly relevant to exercise adherence (Hagger, Wood, Stiff, & Chatzisarantis, 2010).

PBC has been found to predict both intention and actual behaviour in relation to exercise (Armitage, 2005). Additionally, Blue, Wilbur and Marston-Scott (2001) found that attitudes towards exercise and PBC together explained 62 percent of the variance of intention to exercise, and 51 percent of the variance in actual exercise behaviour. PBC has been linked with both health locus of control (Rotter, 1966) and self-efficacy theory (Bandura, 1977). Harkapaa and colleagues (1991) found that people with CLBP who had stronger beliefs in their own personal control over their back pain (i.e. a high internal health locus of control) were more likely to adhere to prescribed home exercise. The concept of self-efficacy suggests that behaviour is directly affected by people's beliefs

about illness and their ability to control their own health (Brannon & Feist, 2009). Self-efficacy theory also proposes that emotion and physiology indirectly affect behaviour through their influence on self-efficacy. Therefore, physiological symptoms experienced when doing exercise could reduce confidence in a person's ability to continue exercising, resulting in non-adherence (Courneya & Friedenreich, 1999).

The TPB has been found to account for only 27 percent of variance in actual exercise behaviour, leaving over 70 percent of variance unexplained (Hagger, Chatzisarantis, & Biddle, 2002). The TBP has been criticised for its emphasis on rational and conscious decision-making (Hall, Fong, Epp, & Elias, 2008; Hall & Fong, 2007; Sutton, 2001). Factors associated with less rational decision-making (e.g. problems with executive functions) have been suggested in an attempt to explain exercise behaviour where traditional health behaviour models have not been successful (Hall et al., 2008). Executive functions are introduced in the next section as one factor that may be particularly relevant to the study of exercise adherence behaviour in CLBP.

### 1.3.2. Self-regulation and executive functions in health behaviours

Self-regulation has been suggested as an important concept that may go some way towards explaining successful exercise behaviour (Hall & Fong, 2010; Hall et al., 2008). Self-regulation is defined as the capacity of an individual to exert control over oneself (Legrain et al., 2009). Control over oneself involves the ability to alter thoughts, feelings and behaviours in order to adapt or adjust behaviours (Nes, Roach, & Segerstrom, 2009). Exercise adherence is a clear example of behaviour that requires self-regulation in order to be successful and where failure to self-regulate may result in non-adherence (Hagger et al., 2010). For example, successful self-regulation may involve overriding a habitual and automatic behaviour (e.g. watching television) and replacing it with the less familiar, but more desired behaviour (e.g. exercise). Circumventing the short-term pleasure of watching television requires effortful control (i.e. the ability to self-regulate) in order to successfully perform exercise behaviour.

Self-regulation takes explanations of health behaviour out of the rational sphere of traditional health behaviour models and into explanations of behaviour based on less rational decision-making (Hall & Fong, 2010; Hall et al., 2008). Self-

regulation has traditionally been investigated in relation to social-cognitive factors to explain the uptake of health behaviours (e.g. implementation intentions in goal-setting) (Gollwitzer, 1999). Implementation intentions have been shown to be a useful aid for individuals where problems self-regulating lead to difficulties successfully performing health behaviours (Sheeran, 2002). However, social-cognitive investigations of self-regulation do not provide any explanation regarding processes that underlie self-regulatory abilities (Hall & Fong, 2007). In order to understand what may contribute to successful self-regulation, it is important to understand the biological processes that control ability to self-regulate.

Ability to self-regulate appears to rely on executive functions (Nes et al., 2009; Hagger et al., 2010; Hofmann, Schmeichel, & Baddeley, 2012). Executive functions are operations of the brain that enable effortful or 'top-down' control of behaviour (Norman & Shallice, 1986, cited in Hall et al., 2008). Effortful behaviour is required for an individual to successfully organise and manage himself or herself to achieve a goal. Furthermore, exercise is an example of a goal-directed behaviour that uses executive functions in order to make effective use of abilities such as planning, problem-solving and behavioural inhibition (McAuley et al., 2011; Hagger et al., 2010). Therefore, it seems logical that executive functions may influence exercise adherence behaviour in a condition such as CLBP, where exercise is a commonly prescribed treatment that requires planning and behavioural inhibition in order to be successful (McAuley et al., 2011).

### 1.3.3. Temporal self-regulation theory

TST is a model based on self-regulation theory (Carver & Scheier, 1982). The TST model is suggested as a useful framework to explain how deficits in executive function lead to difficulties initiating and maintaining exercise behaviour (Hall & Fong, 2010; Hall & Fong, 2007). TST was proposed in response to concerns that traditional models of health behaviour do not account for the role of executive functions in behaviour change (Hall & Fong, 2013; Hall & Fong, 2007). According to the model, behaviour change can be predicted by a combination of social, cognitive and biological factors. Similarly to the TPB, TST states that intention and beliefs play a role in determining health

behaviours. TST also states that control is an important predictor of heath behaviour. However, the TST model posits that executive control, rather than PBC, predicts health behaviours. According to Hall and Fong (2007), executive control consists of two executive functions that are relevant to the successful uptake of health behaviours. These two executive functions are: a) behavioural inhibition (where stronger inhibitory capacity is required for better ability to implement plans) and b) working memory (for the storage and capacity of information, e.g. exercise instructions). The temporal element of the TST model refers to the immediate cost and delayed benefits that are characteristic of exercise behaviours prescribed in CLBP.

The TST model includes a feedback loop that explains how executive function deficits may prevent the initiation and maintenance of exercise behaviour in CLBP. TST posits that individuals with better executive functions are better able to use self-regulation to initiate exercise behaviour. Subsequent exercise behaviour leads to strengthening of executive function and related self-regulatory processes, thus sustaining the feedback loop and leading to maintenance of exercise behaviour in the long-term. The mechanisms of this feedback loop are supported by recent literature indicating that executive functions are required for the initiation of exercise behaviour in healthy samples (Anderson-Hanley et al., 2014; Daly, McMinn, & Allan, 2014; Best, Nagamatsu, & Liu-Ambrose, 2014; McAuley et al., 2011). Furthermore, support for the role of executive functions in the maintenance of exercise behaviour comes from extensive literature displaying bi-directional relationships between aerobic exercise and resistance training and executive functions (e.g. Best et al., 2014; Liu-Ambrose, Nagamatsu, Voss, Khan, & Handy, 2012; Davis et al., 2011; Liu-Ambrose et al., 2010; Smith et al., 2010).

### 1.3.4. Summary of Section 1.3: Models of behaviour change

The current section discussed the limited ability of traditional health behaviour models at predicting exercise behaviour. The present research explores this further by investigating factors not considered by traditional models of behaviour change. In order to do this, the concept of self-regulation was introduced as an explanation why individuals with CLBP may be non-adherent to prescribed home exercise. Ability to self-regulate appears to rely on executive functions

(Nes et al., 2009). Furthermore, the role of executive functions are believed to be particularly relevant in the investigation of exercise behaviour in CLBP (e.g. McAuley et al., 2011). Therefore, the TST model, which integrates self-regulation, executive functions and temporal factors in its explanation of exercise behaviour, was introduced as a health behaviour model relevant to the present research.

## 1.4. Evidence of neurological change and executive function deficits in CLBP

The chronic pain research literature has demonstrated neurological changes and executive functions deficits in CLBP samples (Wand et al., 2011). These findings suggest that ability to self-regulate may be reduced in individuals with CLBP (Nes et al., 2009). Therefore, individuals with CLBP may have difficulties overriding habitual and automatic behaviours in order to successfully carry out exercise behaviour (McAuley et al., 2011; Hagger et al., 2010). Neurological changes in CLBP are important to acknowledge because areas of the brain that have been associated with executive functioning (e.g. the dorsolateral prefrontal cortex [DLPFC]; Kouneiher, Charron, & Koechlin, 2009) have been found to be impaired in individuals with CLBP. Neuroimaging studies provide direct evidence of neurological change in CLBP. Thus, neuroimaging studies provide a robust foundation for studies using executive function tasks to investigate deficits associated with neurological changes. This section provides a brief overview of neurological changes in individuals with CLBP (1.4.1.). Subsequent to this is discussion regarding evidence of executive function deficits that have been found in CLBP samples (1.4.2.).

### 1.4.1. Evidence of neurological changes in CLBP

Neurochemical, structural and functional changes have been found in individuals with CLBP. Neurochemical differences have been found in individuals with CLBP compared to healthy samples (Wand et al., 2011). Grachev and colleagues (2000) found neurochemical differences in the DLPFC, thalamus and orbitofrontal cortex of individuals with CLBP. Furthermore, larger differences were found for individuals with longer duration and intensity of pain or both. Later research by Grachev and colleagues found larger differences also occurred in individuals with co-morbid depression (Grachev, Ramachandran,

Thomas, Szeverenyi, & Fredrickson, 2003) and anxiety (Grachev, Fredrickson, & Apkarian, 2002). These findings are supported by chronic pain research findings that the processing of pain and emotions occur in the same regions of the brain (Apkarian et al., 2004). Furthermore, relationships between pain, anxiety and depression have been shown to be bidirectional (Moriarty, McGuire, & Finn, 2011). Taken together, these findings suggest that the neurological effects of mood may influence the same aspects of executive function that are affected by pain. Therefore, controlling for the effects of mood may be important when investigating executive functions in a CLBP sample.

In addition to neurochemical changes, structural and functional changes have been found in CLBP samples when compared to healthy samples (Wand et al., 2011). Structural neurological changes refer to the influence of grey matter on neural communication (Moriarty et al., 2011). Reductions in grey matter have been found in the DLPFC of individuals with CLBP when compared to healthy controls (Moriarty et al., 2011; Apkarian et al., 2004). Reduced grey matter leads to less efficient neural communication, resulting in poorer performance on executive function tasks (Frodl et al., 2006). Furthermore, altered cortical response to painful stimuli has provided evidence of functional change in CLBP (e.g. Giesecke et al., 2006; Flor, Braun, Elbert, & Birbaumer, 1997). However, in the case of functional change in CLBP, one study found no significant differences between a CLBP sample and a healthy control sample (Derbyshire et al., 2002). Derbyshire and colleagues (2002) found small differences between the CLBP and healthy sample, but these differences were not considered sufficient to indicate change. Reasons for negative findings in studies using positron emission tomography (PET) usually relate to limited sample size or low PET sensitivity at the time of testing (e.g. Silverman et al., 1997, n=12). However, Derbyshire and colleagues (2002) study had an adequate sample (n=32) and improved PET sensitivity compared to earlier studies. Therefore, differences in PET technique across studies were suggested as explanation for their negative findings. Alternatively, it may be that short duration of pain may play a role in the negative findings, as longer duration of pain has been associated with greater neurological change (e.g. Grachev et al., 2000). However, the authors did not state duration of pain for their CLBP sample, therefore, this can only be speculation.

Overall, research evidence suggests that individuals with CLBP have neurochemical, structural and functional changes. These changes are believed to influence both the development and maintenance of chronic pain conditions (Apkarian et al., 2004). However, it is not clear whether neurological changes are a cause or a result of CLBP or other factors (e.g. genetic predisposition) (Apkarian et al., 2004). Neurological changes have been more widely studied in chronic pain conditions other than CLBP (e.g. complex regional pain syndrome and phantom limb pain) (Wand et al., 2011). Therefore, less detailed information is known regarding the extent and implications of these changes in CLBP. Evidently, this is an important area of research to investigate further. Furthermore, longitudinal studies are required to examine the development of neurological changes in relation to initial pain onset and to attempt to assess any causal relationships.

### 1.4.2. Evidence of executive function deficits in CLBP

The present research assumes that executive function deficits that arise from neurological change lead to difficulties adhering to prescribed exercise recommendations for individuals with CLBP. This is because executive function deficits have been found to impact on ability to perform daily tasks that require abilities such as planning, problem-solving and behavioural inhibition (McAuley et al., 2011). Exercise behaviour requires these abilities in order to be successful (Hagger et al., 2010; Hall & Fong, 2007). Thus, executive function deficits are believed to be a potential cause of non-adherence to prescribed home exercise in CLBP. Studies demonstrating executive function deficits in CLBP provide a basis for the investigation of these deficits in the present research.

There is a paucity of research investigating executive function deficits in a solely CLBP population (Berryman et al., 2013; Wand et al., 2011). Nonetheless, evidence overall indicates that individuals with CLBP have executive function deficits when compared to healthy samples. Executive function deficits that have been found in CLBP samples include poor immediate and delayed memory (Weiner, Rudy, Morrow, Slaboda, & Lieber, 2006), poor set-shifting (Weiner et al., 2006), problems of attentional bias (Crombez, Hermans, & Adriaensen, 2000; Roelofs, Peters, Fassaert, & Vlaeyen, 2005), impaired

decision-making abilities (Apkarian et al., 2004) and poor working memory (Wesnes & Annas, 2012; Jorge, Gerard, & Revel, 2009; Dick & Rashiq, 2007). However, one contradictory study found no differences in working memory between a sample of people with CLBP and a healthy control sample (Shuchang et al., 2011). Differences in findings regarding working memory may be for numerous reasons, including differences in the quality of research and differences in participant characteristics. For example, Shuchang and colleagues' (2011) CLBP sample had a lower mean duration of pain (ẋ=3.6 years) than Jorge and colleagues' (2009) (ẋ=5.5 years). Executive functions decline with increasing age, therefore a younger sample are less likely to show evidence of deficit (Hull, Martin, Beier, Lane, & Hamilton, 2008). Additionally, different measures of working memory were used across the four studies. Furthermore, there are problems of clarity regarding which processes are being predominantly assessed by executive function tasks that claim to measure the same process (Chan, Shum, Toulopoulou, & Chen, 2008). This is a limitation relevant to all tasks of executive function and can lead to difficulties concluding exactly which deficits are being assessed by each executive function task (Miyake et al., 2000).

Much of the chronic pain research literature has focused on investigating executive functions in mixed chronic pain samples (Berryman et al., 2013). However, it is difficult to generalise findings from mixed chronic pain samples to CLBP. This has been demonstrated in research finding that executive function deficits are not significant in a mixed chronic pain population, yet they reach significance when investigated in a singular disorder (Jorge et al., 2009; Apkarian et al., 2004; Weiner et al., 2006). The present research should build on current findings regarding executive function deficits in CLBP and provide novel information regarding relationships between executive functions and exercise adherence behaviour in a CLBP sample. It is acknowledged that multiple factors (e.g. depression and anxiety) may act as confounding variables in the investigation of executive functions in a chronic pain sample. With this in mind, this thesis investigates executive functions (e.g. behavioural inhibition and working memory), psychosocial factors (e.g. beliefs and mood) and clinical factors (i.e. pain and disability) and their relationships with prescribed home exercise in a CLBP sample.

### 1.4.3. Summary of Section 1.4: Evidence of executive function deficits and neurological changes in CLBP

This chapter introduced the issue of CLBP and its substantial impact on the individual, the NHS and society. The complexities of this area of study were explored in relation to definition, classification and causes of CLBP. Difficulties in determining a cause of CLBP were deliberated through discussion of possible medical and psychological causes. Different physiotherapy treatments for CLBP were then discussed, with a focus on prescribed exercise treatment which is the focus of the present research. Finally, exercise programmes in general were found to be effective at improving clinical outcome (e.g. pain and disability) for individuals with CLBP. However, the CLBP research literature has investigated a number of different types of exercise (e.g. supervised and prescribed home exercise). Therefore, results about the effectiveness of exercise programmes cannot be fully generalised to prescribed home exercise is prescribed for CLBP.

Adherence to prescribed home exercise has been shown to improve clinical outcome in CLBP (Hayden et al., 2005). However, adherence behaviour is seldom assessed in research investigating exercise treatments for CLBP (Beinart et al., 2013; Mannion et al., 2009). The second section of this chapter introduced the concept of non-adherence to prescribed exercise in CLBP. Overall, the CLBP research literature supported the notion that adherence to prescribed home exercise has a positive effect on clinical outcome in CLBP. Interpreting adherence behaviour based on arbitrary dichotomies was suggested to provide a less realistic view of adherence behaviour than interpreting adherence behaviour on a continuum (e.g. Jackson et al., 2014). In addition, findings of extensive overlap between the categories of intentional and unintentional non-adherence behaviour means that caution needs to be applied when applying such distinctions to exercise behaviour.

The limited ability of traditional health behaviour models to predict exercise behaviour led to investigation of self-regulation to explain variance in exercise behaviour. Self-regulation appears to rely on executive functions (Nes et al., 2009; Hagger et al., 2010). Furthermore, exercise is an example of a goal-directed behaviour that uses executive functions in order to make effective use of abilities such as planning, problem-solving and behavioural inhibition

(McAuley et al., 2011; Hagger et al., 2010). Moreover, executive function deficits were shown to impact on ability to perform daily tasks that require abilities necessary for successful exercise behaviour (e.g. planning, problem-solving and behavioural inhibition) (McAuley et al., 2011). Therefore, evidence of neurological changes and executive function deficits in CLBP were considered to provide a robust foundation for the present research to investigate these issues in relation to exercise adherence behaviour.

## 1.5. Research objectives and hypothesis

CLBP is difficult to treat and 80 percent of people with CLBP are likely to have recurrent symptoms throughout their lives (Waddell & Schoene, 1998). Adherence to prescribed home exercise programmes is important for patients to maintain lasting benefits (Friedrich et al., 2005). However, between 50 percent (Friedrich et al., 1998) and 70 percent (Harkapaa et al., 1991; Reilly et al., 1989) of individuals with CLBP do not adhere to prescribed home exercises. Few studies have investigated factors that influence adherence to prescribed home exercise in CLBP (Mannion et al., 2009). Consequently, there is a lack of detailed information that may assist clinical practice in the treatment of CLBP.

This thesis aims to address gaps in the CLBP research literature by conducting three studies. Study 1 describes a systematic review that identifies factors that have been shown to influence prescribed home exercise in CLBP samples (Research objective 1, Chapter 3) (1.5.1.). Study 2 described the development and initial psychometric evaluation of a measure to assess exercise adherence behaviour in CLBP (Research Objective 2, Chapter 4) (1.5.2.). Study 3 investigates executive function, psychosocial and clinical factors predicting prescribed home exercise in a CLBP sample (Research Objectives 3-5, Chapters 5-7). Research Objective 3 is investigated using baseline data from Study 3 (1.5.3). Research Objectives 4 (1.5.4.) and 5 (1.5.5.) utilise baseline and longitudinal data from Study 3. A summary briefly reiterates the structure of the remainder of this thesis (1.5.6.).

### 1.5.1. Research Objective 1 (Study 1)

To identify the factors which have been found to influence adherence to prescribed home exercise in CLBP.

There is no systematic review that investigates factors influencing exercise behaviour in individuals with CLBP. Consequently, the first objective is to conduct a systematic review investigating individual and intervention-related factors associated with adherence to prescribed home exercise in CLBP. The results of this review are expected to provide a greater understanding about the complex factors influencing adherence to prescribed home exercise.

### 1.5.2. Research Objective 2 (Study 2)

To develop a measure to assess adherence to prescribed home exercise in CLBP.

The lack of valid and reliable measures of exercise adherence behaviour demonstrates the necessity for a standardised, validated measure to be developed for use in future studies investigating prescribed exercise (Jordan et al., 2010). Furthermore, use of a validated measure of exercise adherence behaviour should add robustness to findings in a field of research where reliability of current results are hindered by lack of a standardised measurement tool. Consequently, the second objective is to develop and psychometrically evaluate a self-report measure of adherence to prescribed home exercise in CLBP (the Exercise Adherence Rating Scale, the EARS). This measure is used to assess exercise adherence behaviour in Study 3.

### 1.5.3. Research Objective 3 (Study 3)

To assess and examine relationships between psychosocial, clinical and executive function factors in individuals with CLBP.

CLBP is characterised by debilitating levels of self-reported pain and disability (Savigny et al., 2009). Psychosocial factors (e.g. anxiety, depression, beliefs, fear-avoidance beliefs and pain catastrophizing) have been associated with the maintenance of pain and disability in CLBP (e.g. Tangestani, 2012; Thomas et al., 2010). Additionally, individuals with CLBP display neurological changes and executive function deficits that may lead to difficulties following treatment advice, such as advice to exercise (Hagger et al., 2010; Hall et al., 2008). Therefore, the focus of the third research objective is to assess and examine relationships between psychosocial, clinical and executive function factors prior to physiotherapy treatment in a sample of adults with CLBP. This cross-

sectional analysis allows for the comparison of the CLBP sample to normative data and other CLBP samples. Additionally, correlational analysis provides insights into relationships between psychosocial, clinical and executive function factors in CLBP.

### 1.5.4. Research Objective 4 (Study 3)

To evaluate the possible roles of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in CLBP.

Psychosocial factors (e.g. distress) and clinical factors (i.e. pain and disability) have been associated with adherence to prescribed home exercise in CLBP (Beinart et al., 2013). Executive functions have been found to predict exercise behaviour in a healthy sample (Hall et al., 2008). The influence of executive functions is posited to be particularly relevant to exercise behaviour in a CLBP sample because executive function deficits have been found in individuals with CLBP (Wand et al., 2011). Therefore, the fourth research objective investigates the predictive value of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in a CLBP sample. This is tested by construction of multiple regression models with predictors based on theoretical and statistical rationales.

### 1.5.5. Research Objective 5 (Study 3)

To determine whether adherence to prescribed home exercise is related to clinical outcome.

Relationships between clinical outcome and exercise adherence behaviour have rarely been assessed. The few studies that have investigation these relationships found no relationships between changes in clinical outcome and adherence (Mailloux, Finno, & Rainville, 2006) and inverse relationships between disability (Harkapaa et al., 1991), pain (Donzelli, Di Domenica, Cova, Galletti, & Giunta, 2006) and subsequent adherence behaviour. Exercise is a main treatment prescribed to treat CLBP (NICE, 2009). Lack of research in this area indicates that further investigations are necessary to improve understanding of relationships between clinical factors that characterise CLBP as a chronic condition (i.e. pain and disability) and exercise adherence behaviour. Thus, the fifth research objective assesses relationships between

adherence to prescribed home exercise and self-reported disability and pain. Correlational analysis investigates relationships between baseline clinical factors and changes in clinical factors over time and subsequent adherence behaviour.

### 1.5.6. Hypothesis (Study 3)

Executive functions will predict additional variance in adherence behaviour over and above that which is explained by psychosocial and clinical factors.

Much of the research investigating relationships between executive functions and health exercise behaviours has focused on the positive effects of exercise on executive function processes in healthy samples (Buckley, Cohen, Kramer, McAuley, & Mullen, 2014). Less research has investigated the influence of executive functions on exercise behaviour (Hall et al., 2008; Hall & Fong, 2007). However, preliminary evidence has found that executive functions are predictive of exercise behaviour in healthy samples (McAuley et al., 2011; Riggs, Chou, Spruijt-Metz, & Pentz, 2010; Hall et al., 2008). Therefore, in Study 3, executive functions are posited to predict additional variance in adherence behaviour over and above that which is explained by psychosocial and clinical factors.

### 1.5.7. Recap: Structure of thesis

This chapter discussed research evidence to provide rationales for further study of adherence to prescribed home exercise in a CLBP sample. The succeeding seven chapters describe three studies, beginning with a discussion of the methodological considerations of the present research (Chapter 2). Study 1 then presents a systematic review that identifies factors that have been shown to influence prescribed home exercise in CLBP samples (Chapter 3). Study 2 describes the development and initial psychometric evaluation of a measure to assess exercise adherence behaviour in CLBP (Chapter 4). Study 3 investigates executive function, psychosocial and clinical factors predicting prescribed home exercise in a CLBP sample (Chapters 5-7). Finally, an overall discussion brings together the findings of this thesis and implications of the research and directions for future research are discussed (Chapter 8).

# 2. Methodology

This chapter describes methodological considerations relevant to the planning of the three studies conducted for this thesis. The three studies are: a systematic review (Study 1, Chapter 3); the development and initial psychometric evaluation of a measure to assess adherence to exercise (Study 2, Chapter 4); and a study assessing the role of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in chronic low back pain (CLBP) (Study 3, Chapters 5 - 7). The first section discusses methodological considerations regarding methods used in each of the three studies (2.1.). This section includes discussion of narrative versus systematic reviews (Study 1), idiographic and nomothetic methods of questionnaire development (Study 2) and quantitative versus qualitative methods (Study 3). Methodological considerations relevant to the quantitative methods used in Study 3 are then examined (2.2.). This section includes discussion of issues such as participant burden, measurement reactivity, response bias, mode and context of questionnaire administration and social desirability bias. The next section discusses methodological considerations (e.g. issues of definition and psychometric concerns) regarding the assessment of executive functions in Study 3 (2.3.). The discussion then focuses on statistical considerations relevant to all three studies (2.4.). This section briefly describes methodological considerations of missing data and interpretation of effect sizes in relation to the present research. Lastly, the methodological considerations discussed in this chapter are summarised.

## 2.1. Methodological considerations in the present research

This section discusses methodological considerations relevant to each of the three studies conducted for this thesis. Firstly, the advantages and disadvantages of narrative versus systematic reviews are discussed (2.1.1.). The methodological considerations that were considered throughout the process of conducting the systematic review for Study 1 are then explored. Secondly, Study 2 is discussed in relation to the nomothetic assessment of exercise adherence behaviour (2.1.2.). Nomothetic and idiographic methods are discussed in relation to the development of the EARS. Lastly, discussion

focuses on qualitative methods of executive function assessment for Study 3 (2.1.3.).

### 2.1.1. Study 1: A systematic review

The systematic review conducted for Study 1 provides a summary of evidence regarding factors associated with adherence to home exercise in CLBP. A systematic review, rather than a narrative review, was selected in order to provide a detailed and less biased summary of CLBP research investigating adherence to prescribed home exercise. A narrative review has its own advantages, for example, providing a broader overview of research than may be provided by a systematic review (Garg, Hackam, & Tonelli, 2008). However, the process of compiling a narrative review is an implicit process. Therefore, the researcher's own judgements and views are likely to play a role in the selection of studies to be included in the review. This leads to difficulties understanding how studies were identified and whether certain studies were emphasised more than others (Garg et al., 2008).

A systematic review was chosen for Study 1 as it is an explicit process based on a clearly formulated question that uses systematic methods to 'identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review' (Green and Higgins, 2005 cited in Moher, Liberati, Tetzlaff, & Altman, 2009). Another reason for conducting a systematic review was that it would provide information regarding the consistency of research findings throughout CLBP samples. This was considered particularly important in the case of the present research where there is little research investigating exercise adherence behaviour in CLBP. Bias remains a problem when conducting any type of review. However, the explicit nature of a systematic review allows readers of the review to more easily explore sources of potential bias than a narrative review (Garg et al., 2008). Methodological issues that were considered when conducting the systematic review related to the various biases involved in the process of conducting a systematic review. In the case of the present research, key challenges included locating relevant research literature and finding a suitable tool to assess the quality of articles.

Finding relevant literature is essential to the efficacy of a systematic review. This can be a time consuming task and requires careful consideration of resources. For example, translation services would be required to ensure a comprehensive review of all relevant literature. However, lack of resources meant that this was not possible in the case of the present research. Additionally, bias was an important consideration when conducting a systematic review. Bias can occur at various stages of a systematic review, starting with selection of studies based on search criteria. To overcome this, guidance recommended by Smith and colleagues (2011) was followed to reduce risk of bias at each stage of the review process. For example, prior to deciding what search terms to use, key journals (e.g. The Spine Journal, The European Spine Journal and Manual Therapy) were searched for relevant articles and references of these articles were examined. These articles and their references provided useful information that informed the search strategy and ensured more inclusive search terms.

Quality assessment of the research literature was an area that was considered to be particularly difficult when it came to avoiding bias. Attempts were made to disregard certain factors (e.g. the journal title and authors of an article) so that the quality of the study was not pre-judged. However, no valid and reliable quality assessment tool (QAT) was found to be suitable for the purposes of the systematic review in Study 1. Therefore, a modified tool had to be considered to allow for the inclusion of important criteria relevant to physical therapy interventions that were found to be lacking in other QATs (see Appendix 3 for more information). This is an example of one methodological consideration where advantages of using an all-inclusive QAT had to be compared to the disadvantages of using a validated QAT that did not assess important areas of each article (e.g. whether or not a sample size calculation was provided).

Two main challenges of conducting the systematic review in Study 1 related to locating relevant research literature and finding a suitable tool to assess the quality of articles. However, other methodological considerations were also considered when conducting the systematic review in Study 1. For example, searching multiple databases and systematically updating the search prior to

publication (Tricco et al., 2008). The researcher attempted to minimize bias by accounting for multiple methodological considerations related to conducting a systematic review. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines were followed when conducting and reporting the systematic review with the aim of producing a well-conducted review with limited risk of bias.

### 2.1.2. Study 2: The development of a questionnaire

This systematic review conducted in Study 1 highlighted the lack of standardised measures of adherence to prescribed home exercise for individuals with CLBP. This resulted in Study 2 and the development of the Exercise Adherence Rating Scale (EARS).

Psychological assessment can be explained in terms of being essentially nomothetic or idiographic (Haynes & O'Brien, 2002). The term nomothetic is used to describe standard tools developed using groups of individuals with a common characteristic (e.g. in the case of the present research, CLBP). Whereas, the term idiographic describes methods used with an individual in a specific situation where no predictions can be made from resulting scores for anyone other than that individual (Goldstein, Beers, & Herse, 2004). The present research aims to produce a measure of exercise adherence behaviour that is standardised across a CLBP sample and assesses the same construct (i.e. adherence behaviour) on the same dimensions across that sample. This is turn will produce a tool that can be used across individuals with CLBP. Thus, the EARS is developed to be an essentially nomothetic tool, as it is concerned with identifying general 'laws' about behaviour that can be used to predict how a group of similar individuals may behave in the same situation ('nomos' is Greek for 'law').

The development of a questionnaire typically involves a mixed methods (i.e. qualitative and quantitative) approach. Qualitative methods (e.g. interviews and focus groups) are generally considered to be idiographic methods, whereas quantitative methods (e.g. psychometric evaluation) are considered to be nomothetic methods (Hayes, 2000). Therefore, although the EARS is regarded

as a nomothetic tool in terms of its application, methods used in the development of the EARS were both nomothetic and idiographic. Three steps were followed for the development of the EARS (Granquist, Gill, & Appaneal, 2010). First, qualitative methods were used to generate initial items from individuals with CLBP and physiotherapists. Second, these items were reviewed by clinical experts and a small sample of different individuals with CLBP. Third, the final set of items were administered to a large sample of individuals with CLBP for preliminary psychometric evaluation. This section briefly discusses qualitative methods considered in the initial stages of development of the EARS. Methodological considerations of quantitative methods used in the present research (i.e. self-report questionnaires and executive function tasks) are discussed in detail later in this chapter.

Interviews and focus groups were considered as qualitative methods of data collection in the initial stages of the EARS. Collecting greater information over a shorter time was crucial to time constraints of the present PhD. However, interviews were contemplated to facilitate the collection of in-depth data about adherence behaviour. Three main types of interview were considered. These were in-depth interviews, semi-structured interviews and unstructured interviews (Mason, 2002). Each type of interview came with its own advantages and disadvantages. However, interviews appeared more useful for topics where very little is known, or topics that are being investigated from an unusual angle (Nassar-McMillan & Borders, 2002). Furthermore, problems regarding subtle power relationships between the interviewee and interviewer may be experienced during the interview process (Hayes, 2000). This can result in the interviewee saying 'the right thing' to please the interviewer, rather than discussing reality as they see it. This is related to the notion that interviews may not represent reality as much as they represent a person's ability to verbalise, communicate, interact and remember (Mason, 2002). For these reasons, focus groups were considered more suitable for the purposes of Study 2.

Focus groups were considered advantageous over interviews as certain information regarding factors influencing adherence behaviour in CLBP was provided by the systematic review carried out for Study 1. Furthermore, the group dynamic of focus groups was expected to produce a greater range of

ideas based on interactions amongst the group (Webb & Kevern, 2001). This is closely related to the notion that group interaction has been shown to 'accelerate the natural social processes by which individuals compare opinions of each other' (Doyle 2004, cited in Krueger & Casey, 2009). Therefore, focus groups were expected to produce greater information, with a wide diversity of opinion, over a shorter time frame than interviews (Krueger & Casey, 2009).

### 2.1.3. Study 3: A study assessing exercise adherence behaviour in CLBP

Study 3 investigated the role of executive function, clinical and psychosocial factors in adherence to prescribed home exercise for CLBP. Quantitative methods were necessary in order to obtain suitable data to test the research objective and hypothesis for Study 3. However, qualitative methods were considered to provide further data over and above that provided by executive function tasks. Therefore, qualitative assessment of executive functions is briefly discussed (2.1.3.1), prior to detailed discussion of methodological considerations of quantitative methods used in Study 3.

Qualitative assessment of executive functions is considered a relatively straightforward process when used with individuals with evident executive function deficits where a considerable amount is known about the deficits and their related behaviours. For example, a vast amount of research has investigated executive function deficits in individuals with Autism Spectrum Disorders (ASD) (e.g. Pellicano, 2012; Gilotty, Kenworthy, Sirian, Black, & Wagner, 2002). This research has provided detailed information regarding certain types of behaviour related to specific executive function deficits in ASD. For example, individuals with high-functioning Autism may be told up to 100 times that they are using an incorrect strategy for solving a particular problem on an executive function task. However, participants with high-functioning Autism are likely to continue to persevere with their incorrect strategy until the task is removed by the examiner (Minshew, Goldstein, & Siegel, 1999).

Level of perseverance can be noted by the researcher as one example of qualitative data in addition to quantitative findings from an executive function task. However, qualitative assessment of executive functions becomes a

relatively subjective process when used in samples that do not have obvious executive function deficits. A healthcare professional with clinical experience of micro-analytic techniques would be required to obtain reliable qualitative data from executive function testing (Anderson, Jacobs, & Anderson, 2011). Lack of appropriate resources and expertise deemed this type of qualitative testing to be out of scope of the present research. Therefore, Study 3 relied mainly on quantitative methods of assessment. The remainder of this chapter therefore focuses on methodological considerations of quantitative research methods for Study 3.

## 2.2. Methodological considerations of quantitative methods used in Study 3

This section discusses methodological issues relating to self-report questionnaires that were used in Study 3. Firstly, participant burden is discussed in relation to baseline assessment of psychosocial, clinical and executive function measures for Study 3 (2.2.1.). Secondly, discussion focuses on methodological considerations of self-report measures (2.2.2.). The importance of acknowledging methodological issues in the present research is then reiterated in a section summary (2.2.3.).

### 2.2.1. Participant burden

Self-report questionnaires and executive function tasks were quantitative methods selected to assess psychosocial, clinical, executive function factors and adherence behaviour in Study 3. Multiple measures were required to assess these variables. Thus, participant time and fatigue were important considerations for three main reasons. Firstly, individuals with chronic pain may have fatigue associated with pain or other issues related to their condition. Therefore, it was important that fatigue due to participation in the present research was minimal and acceptable to the participant. Secondly, participants may be unable to attend fully to the questionnaires and tasks if they become fatigued throughout the testing process. Participants are unlikely to respond favourably to requests for follow-up if they experience negative issues during baseline testing. Thirdly, it was important that participation in the study did not negatively impact on subsequent physiotherapy treatment. For example,

negative experiences during baseline testing may reflect badly on the physiotherapy department in general, thus potentially influencing decisions regarding attendance to appointments and adherence to treatment recommendations. Physiotherapists and individuals with CLBP were asked to state their opinions about the length and time of baseline and follow-up testing for Study 3. Preliminary patient and public involvement work found that physiotherapists and patients with CLBP felt that it was acceptable for participants to spend a maximum of 45 to 60 minutes completing baseline measures.

### 2.2.2. Self-report measures

Self-report measures were the practical choice for assessing psychosocial and clinical factors in Study 3. However, self-report measures are subject to a number of methodological limitations, which are discussed in this section. Methodological considerations are discussed in relation to problems of measurement reactivity (2.2.2.1.), response bias (2.2.2.2.), mode and context of administration (2.2.2.3.), interpretation and comprehension of questionnaires (2.2.2.4.) and social desirability bias (2.2.2.5.). Methods of reducing the impact of these considerations in the present research are also described.

#### 2.2.2.1. Measurement reactivity

Measurement of psychological variables has been described as a 'reactive' process due to its influence on people's emotions, thoughts and behaviour (French & Sutton, 2010). Examples that are particularly relevant to the present research refer to the assessment of mood and exercise adherence. For example, anxiety and depression scores have been shown to vary depending on where assessment of mood occurs within a battery of questionnaires (Johnston, 1999; Sharpe & Gilbert, 1998). Furthermore, the very act of completing a questionnaire that includes potentially emotional topics may lead to a high score that is an inaccurate report of an individual's true emotional state (French & Sutton, 2010). Examples where measurement reactivity has been found to influence behaviour comes from studies where pedometers lead to an increase in exercise behaviour, even though are not intended to act as a physical activity intervention (Bravata et al., 2007). This is relevant to the

present study where the use of objective measures were considered to assess adherence behaviour. However, the review by Bravata and colleagues' (2007) suggested that use of an objective measure may increase average adherence score across the sample, thus producing an inaccurate report of natural adherence behaviour in the absence of pedometer use. The issue of objective measurement of adherence behaviour is discussed in more detail later in this thesis (Chapters 4, 7 and 8).

Methods that have been suggested to overcome bias caused by measurement reactivity in non-experimental research include counterbalancing of measures and specific placement of reactive measures. Counterbalancing is most commonly used in repeated measures designs to control for order effects. This was not relevant for Study 3, where a battery of questionnaires and executive function tests were completed at baseline only. However, placement of measures was particularly relevant where measures assessed a range of variables that could be thought of as reactive (e.g. anxiety, depression, pain catastrophizing). Furthermore, executive function tasks have not been described in terms of reactivity, but it seems logical that they may include an element of frustration and embarrassment for individuals who find tasks difficult to complete.

Johnston and colleagues (2004) suggested placing measures that appear most reactive at the beginning of a test battery in order to reduce the effects of measurement reactivity. However, all psychosocial and clinical measures within the test battery were found to contain some element of reactivity when reviewed by researchers and individuals with CLBP prior to baseline assessment for Study 3. A further related issue was whether executive function measures should be placed before, throughout or after, the psychosocial and clinical measures. As relatively little is known about measurement reactivity with respect to measurement of executive functions, Johnston and colleagues' (2004) recommendations regarding the placement of reactive measures at the beginning of the entire test battery. Counterbalancing may reduce, but not eliminate the effects of measurement reactivity (French & Sutton, 2010). However, there is no robust evidence base to assist in deciding the most suitable order of measures to reduce the impact of measurement reactivity. Furthermore, there was no consensus in the research literature regarding

different levels of reactivity for psychosocial and clinical measures. There was not enough time to investigate this further. Evidently, measurement reactivity introduces a range of biases that should be acknowledged in questionnaire-based research. This is closely related to other methodological considerations of questionnaire-based studies that may lead to inaccurate report of behaviours, discussed below.

#### 2.2.2.2. Problems of response bias

There are various reasons why an individual may respond to a questionnaire item inaccurately, thus producing response bias. Four key factors have been suggested to cause response bias. These are memory (e.g. forgetting or remembering incorrectly), motivation (e.g. wanting to present oneself in a certain way, or willingness to answer questions), knowledge (e.g. answering a question even when unsure of the correct response) and understanding (i.e. failing to understand the meaning of the question) (Organisation for Economic Co-operation and Development [OECD], 2013; Bradburn, Sudman, & Wansink, 2004). Within these four constructs are numerous features that were considered when selecting measures for the present research and developing the test battery. These components included the mode and context of administration of the test battery, an understanding of the definition of broad concepts (e.g. pain and distress) and related to definition, the reliability and validity of selected measures.

#### 2.2.2.3. Mode and context of administration

All selected questionnaires were self-report measures that could have the potential to be completed by the participant in their own time, either online or using pen and paper. Different modes of administration have advantages (e.g. participants completing measures in their own time) and disadvantages (e.g. difficulties of online access for some participants). However, the executive function tasks required interaction with the researcher. Furthermore, the psychosocial, clinical and executive function measures required completion in the same sitting so that relationships between variables could be accurately assessed. For example, level of pain has been shown to influence working memory (Dick & Rashiq, 2007). However, variations in pain mean that this

relationship could not be reliably assessed if these two variables were assessed at different times. Moreover, it was necessary for measures to be completed prior to each participant's first physiotherapy appointment, as this provided baseline data that needed not to be confounded by physiotherapy treatment. For example, in-clinic exercise or prescribed home exercise may influence pain level (Waddell et al., 1993) and consequently influence answers to items associated with pain. Additionally, information from the physiotherapist may influence a patient's beliefs and understanding of their illness and treatment, thus influencing related responses.

Participants attended baseline testing for Study 3 in a quiet room in, or near to, the physiotherapy department where they would have their subsequent physiotherapy appointment (i.e. one-to-one physiotherapy or a group back class). Therefore, all testing occurred in a hospital setting, which may have provided a contextual cue leading participants to consider their health when completing the questionnaires. This was an advantage of assessing participants in a health-care setting compared to a less controlled setting (e.g. completing questionnaires at home or work) where distractions may lead to less attention and inaccurate responses. A further advantage related to completion of measures with the researcher present. This was useful to reduce the risk of lack of knowledge and misunderstanding of items as the researcher was available to answer any questions. However, further bias may arise from different levels of information given to participants who ask questions versus those who ask few, or no, questions when completing the questionnaires. In order to lessen this risk of bias, interpretation and comprehension of each questionnaire was considered before inclusion into the test battery.

#### 2.2.2.4. Interpretation and comprehension of questionnaires

To reduce problems of misinterpretation, questionnaires were piloted with ten individuals with CLBP to assess face validity. Four out of the ten individuals asked the researcher to clarify items on one questionnaire. This was the first section of the Short Form McGill Pain Questionnaire (SF-MPQ, Melzack, 1987), where participants are asked to note which pain-related words relate most to their pain experience (e.g. shooting, cramping, splitting and fearful). Issues of comprehension were already known regarding the SF-MPQ. For example,

inadequate completion of the SF-MPQ has been found in postal questionnaires received by a UK sample of patients with osteoarthritis (Grafton, Foster, & Wright, 2005). They found that certain pain-related words were unfamiliar to patients. However, patients who were given verbal instructions and completed the questionnaire in-clinic were less likely to make errors. The SF-MPQ is a well-validated and reliable questionnaire for the assessment of pain in a CLBP sample. The SF-MPQ was therefore deemed to be the most suitable pain measure for the present research. Problems of interpretation and comprehension were expected to be reduced by the researcher being present to answer any questions that arose.

#### 2.2.2.5. Social desirability bias

Contextual cues may also relate to less intentional methods that participants may use when seeking an understanding of what meaning is intended for each item. For example, meaning may be sought from the available responses for an item or from other questions in the questionnaire or test battery. Item order and the wording of items may also provide inadvertent contextual cues. These contextual cues, plus the proximity of the researcher in the testing environment, may lead to a social desirability bias (OECD, 2013). Social desirability bias refers to the conscious or unconscious representation of oneself in a favourable light (Johnson, Fendrich, & Hubbell, 2002). Social desirability bias may occur in the present research for several reasons. Firstly, participants may wish to present themselves in a positive light to the researcher or, in this case, their physiotherapist. Secondly, participants may believe that their answers could affect future physiotherapy treatment. Thirdly, information given to participants prior to their testing session may promote a socially desirable response. Fourthly, the wider context of social norms may lead to answers based on what participants feel is appropriate to their wider social group.

The present research attempted to reduce social desirability bias in a number of ways. However, it was recognised that certain aspects of bias can be acknowledged, but may not be easily reduced (e.g. wishing to represent oneself in a positive way to the researcher). Participants were assured that their contributions to the research would remain anonymous and confidential. This was done in writing on the information sheet (Appendix 1) given to participants

prior to testing and also in person at the time of testing. The information sheet was carefully worded to explain the purpose of the research, whilst not eliciting a certain type of response to questions that may be asked by questionnaires. For example, it was explained that individuals with CLBP are expected to have different views regarding their treatment and that this research is attempting to better understand these differing views. It was anticipated that the expectation of differing views may lead participants to feel less compelled to answer items based on socially desirable responses and thus to provide more accurate responses.

A further issue of social desirability bias may be found in research assessing mental health disorders. This is particularly relevant to the present research where anxiety and depression are assessed as potential co-morbid symptoms of CLBP. Social stigmas regarding mental health disorders, in particular depression, are considered to be a greater problem in the UK than in any other European country (Mental Health Foundation, 2015). Stigma has been shown to lead to concealment of psychiatric history (Alverson, Becker, & Drake, 1995). Furthermore, individuals who perceive stigma to be attached to their condition are less likely to seek treatment (e.g. Meltzer et al., 2000). However, not all studies have found this to be the case (Roeloffs et al., 2003). Measures to assess depression were carefully considered as it was believed that assessment of factors relating to severe depression (e.g. suicidal thoughts) may cause participants unnecessary emotional distress.

The decision to consider measures of depression that did not assess severe symptoms of depressive disorders may have had the additional benefit of reducing issues of social desirability bias based on social stigma. This relates in some part to contextual cues such as item order and the wording of items. For example, the Hospital Anxiety and Depression Questionnaire (HADS; Zigmond & Snaith, 1983) was selected for use in the present study. Positive and negative items that assess anxiety and depression are interspersed within the HADS. The inclusion of positive items on the HADS (e.g. “I feel cheerful”) gives the opportunity to answer negatively (i.e. not at all, not often, sometimes, most of the time) whilst still assessing depression. This is in contrast to the Beck Depression Inventory (BDI; Beck, Ward, & Mendelson, 1961) that includes a negatively worded list of items (e.g. “I don’t feel like I am being punished” and “I

don't have any thoughts of killing myself"). Positively weighted items in the HADS may provide a buffer to reduce the likelihood of stigma relating to depression being at the forefront of one's mind when answering the questions. This has been supported by findings that wording items in a less threatening way increases socially undesirable responses (Peter & Valkenburg, 2011; Holbrook & Krosnick, 2010). For the reasons described above, the HADS was chosen to assess anxiety, depression and overall distress in Study 3.

### 2.2.3. Summary of Section 2.2: Methodological considerations of quantitative methods

This section discussed methodological considerations regarding self-report questionnaires used in the present research. Problems of measurement reactivity, response bias, mode and context of administration, interpretation and comprehension of questionnaires and social desirability bias were discussed. Measures were taken to reduce the impact of bias due to these methodological limitations. This included piloting of the entire test battery to assess appropriate order of questionnaires, plus comprehension and interpretation of questionnaires. Methodological considerations relating to the wider environment (e.g. the weather and life events) were not discussed in this section (OECD, 2013). However, it was recognised throughout the research process that even though measures were taken to reduce bias where possible, numerous biases remained that must be acknowledged when interpreting the findings of the present research.

## 2.3. Methodological considerations regarding assessment of executive functions

Executive functions are operations of the brain that enable effortful, or 'top-down' control of behaviour (Norman & Shallice, 1986, cited in Hall et al., 2008). The assessment of executive functions shares certain methodological considerations with questionnaire-based research, but also comes with its own set of considerations that are specific to the field of executive function research. Assessment of executive functions is a complex and challenging process (Miyake & Friedman, 2012). Considerable advances in neurological testing have led to research investigating relationships between neurological concerns

and executive function tasks (e.g. Rosano et al., 2012). A brief overview of executive function assessment provides context to subsequent discussion of methodological considerations regarding executive functions (2.3.1.). The current section discusses methodological considerations related to definition of executive functions (2.3.2.), psychometric problems including issues of internal and ecological validity, plus test-retest reliability of executive function tasks (2.3.3.). Last, methodological considerations regarding assessment of executive functions are summarised (2.3.4.).

### 2.3.1. Overview of executive function assessment

Over the past decade there has been significant progress in our understanding of executive functions (Testa, Bennett, & Ponsford, 2012). Executive functions have historically been considered as unitary abilities that can be assessed using a single executive function task (Teuber, 1972). This suggests that executive functions are reflections of the same underlying ability. However, more recent research suggests that executive functions are more accurately characterised as a group of connected, but separable, abilities (Friedman et al., 2008; 2006; Miyake et al., 2000). For example, tests such as the Tower of Hanoi (ToH) (Davis & Keller, 1998), the Wisconsin Card Sorting Test (WCST) and the random number generation test (RNG) (Ginsburg & Karpiuk, 1994) have previously been believed to measure numerous executive function deficits. However, research by Miyake and colleagues (2000) found that these three tests correlated with each other, but also predominantly assessed separate components of executive function (i.e. inhibiting, sorting and updating respectively). This has led to important consequences for the measurement of executive functions. Executive function tests are now often used to assess specific areas of executive function, providing more precise information about the nature of executive deficits in patient groups. Consequently, it is considered best practice to assess executive functions using multiple tasks as part of a comprehensive test battery in order to improve the likelihood of capturing existing deficit (Pickens, Ostwald, Murphy-Pace, & Bergstrom, 2010; Halligan & Wade, 2005; Royall et al., 2002).

### 2.3.2. The problem of definition

A key challenge to the study of executive functions is the lack of a universally accepted definition (Pickens et al., 2010). Lack of definition has intensified problems of validity and reliability of executive function tasks leading to methodological challenges regarding the assessment of executive functions (Chan et al., 2008). It has been argued that executive functions are difficult to define due to considerable overlap between executive function processes (Rajeswaran, 2012). Boundaries between different executive function processes are argued to be unclear (Meltzer, 2011). This has led to multiple executive function processes being assessed by individual executive function tasks, resulting in lack of clarity regarding which processes are being predominantly assessed (Jurado & Rosselli, 2007). In addition to the aforementioned issues, great variation has been found between the amount and nature of executive function processes across tasks (McCloskey & Perkins, 2012).

Lack of definition of executive functions has led to problems of clarification regarding which factors are predominantly assessed by individual tests of executive function. This, in turn, has led to researchers defining tests of executive function based on their research perspective (Meltzer, 2011). For example, the Stroop Colour-Word (C-W) test has been stated to assess different executive functions depending on the field of enquiry. Areas of executive function that have been assessed by the Stroop C-W test have included behavioural inhibition (Wilkinson & Yang, 2015; Troyer, Leach, & Strauss, 2006), attentional bias (Field & Franken, 2014; Cisler, Bacon, & Williams, 2009), set-shifting (also known as task switching) (Stemme, Deco, & Busch, 2007), cognitive flexibility (Uttl & Graf, 1997), interference (Stroop, 1935; Kravariti et al., 2009) and general executive functioning (Moering, Schinka, Mortimer, & Graves, 2004; Zalonis et al., 2009). This example of the Stroop C-W test demonstrates the challenges of selecting appropriate tasks of executive function for use with a CLBP sample in Study 3.

### 2.3.3. Psychometric problems of executive function tasks

Concerns regarding ecological validity of executive function tasks have resulted in the common criticism that these tasks are inadequate for the prediction of daily difficulties (Jovanovski, 2010; Chaytor, Schmitter-Edgecombe, & Burr,

2006; Burgess, Alderman, Evans, Emslie, & Wilson, 1998; Chan et al., 2008). Research findings have been inconsistent regarding relationships between various executive function tasks and areas of daily living that are asserted to be assessed by the tasks (Chan et al., 2008). Research assessing executive functions in patients with frontal-lobe damage have found successful completion of executive function tasks (e.g. the WCST) has been inversely correlated with related problems of daily functioning (e.g. Shallice & Burgess, 1991). Similar results have been found using multiple executive function tasks in an older sample (e.g. Amieva, Phillips, & Della Sala, 2003) and a brain-injured sample (Norris & Tate, 2000). In contrast, poor performance on executive function tasks has been inversely correlated with daily functioning in individuals with frontal-lobe damage (e.g. Chaytor et al., 2006). Further research has found that executive function tasks have correlated positively with clinician ratings of performance on daily tasks using the Neurobehavioral Rating Scale (NRS) for patients with schizophrenia (Dimitrov, Grafman, & Hollnagel, 1996).

Inconsistencies in research assessing the ecological validity of executive function tasks demonstrates difficulties that are encountered when attempting to select tasks that correlate with tasks of daily functioning. Ecological validity has been assessed across a range of samples and using multiple executive function tasks. In addition to this, versions of tests and methods of administration are likely to vary across studies. Where executive function tasks and daily functioning task have correlated positively, effect sizes have been moderate to large (i.e. r = .3 to .6) (Chaytor et al., 2006). This demonstrates that much of the variance in daily functioning tasks is not accounted for by executive function tasks. A key goal of executive function testing is to predict an individual's daily life functioning (Lamberts, Evans, & Spikman, 2010). However, lack of ecological validity is more easily overcome in a clinical setting where time and expertise allow for a full assessment of a patient using multiple tasks and methods. From a research perspective where time constraints may be an issue, it remains important to select an ecologically valid task that is relevant to deficits expected to be found in the sample in question (Lamberts et al., 2010). Additionally, it should be acknowledged that the testing setting itself reduces the ecological validity of any executive function task (Chan et al., 2008). This is particularly relevant to Study 3 where assessment occurs in a hospital setting.

Limitations regarding internal validity of executive function tasks were acknowledged in the present research. Task-impurity, and problems differentiating between executive function processes assessed by individual tasks, are common limitations of internal validity in executive function research (Miyake & Friedman, 2012). Task impurity occurs when executive function tasks assess not only multiple executive functions, but also non-executive function factors (Miyake & Friedman, 2012). For example, the Stroop C-W Interference Task (Stroop, 1935) is believed to assess numerous executive function processes, plus non-executive function factors such as colour processing and articulation speed. The presence of non-executive function factors lead to difficulties distinguishing which aspects of task performance may be due to executive function processes, and which may be due to measurement error. Miyake and Friedman (2012) have suggested using a latent-variable approach to reduce the impact of task impurity. This involves using multiple tasks that are believed to assess the same underlying executive function process. Techniques, such as confirmatory factor analysis, can then be used to isolate a common factor across tasks. The resulting factor is considered a "purer" latent variable that can be used as an individual measure of the predominant executive function factor. However, using a latent variable approach in the present research would have required additional time and resources in order to recruit a larger sample than originally planned for Study 3. A latent variable approach was not therefore considered suitable for the present research. However, acknowledgement of measurement error due to task impurity was important in order to provide context for findings relating to executive function processes in Study 3.

Further psychometric concerns regarding executive function tasks include their inherent lack of test-retest reliability (Jurado & Rosselli, 2007; Wilson & MacLeod, 2003; Salthouse, Atkinson, & Berish, 2003; Burgess et al., 1998). Burgess and colleagues (1998) argued that executive function tasks can never be reliable because they are designed to assess the ability to manage novel problems. These problems no longer remain novel once the test has been completed in the first instance (Salthouse et al., 2003). Based on this premise, it is suggested that test-retest reliability is of less concern to the psychometric evaluation of executive function tasks than other aspects of psychometric

evaluation (Chan et al., 2008; Wilson, Krabbendam, & Kalff, 1997). However, certain executive function tasks have shown good test-retest reliability, for example, the Hayling Sentence Completion Test (HSCT) (r = .72–.93) (Burgess & Shallice, 1996). This suggests that the HSCT does not adequately assess ability to manage novel problems. Therefore, it may be an inadequate assessment of executive functions. Alternatively, perhaps executive function tasks should not be so rigidly defined by their ability to assess behaviour in novel situations. This returns to the issue of lack of a universally accepted definition of executive functions, further demonstrating the multitude of methodological challenges that were considered when selecting measures to assess executive functions for Study 3 of the present research.

### 2.3.4. Summary of Section 2.3: Methodological considerations of executive function assessment

This section described methodological considerations related to definition of executive functions and psychometric issues that affect executive function tasks. Issues of internal and ecological validity, plus test-retest reliability, of executive function tasks were discussed. These methodological considerations were deliberated during the planning of Study 3. Multiple tasks were necessary to effectively assess executive functions. It was important for tasks to be psychometrically robust and ecologically valid where such tasks were available. Tasks were only selected if considered acceptable in terms of participant burden (e.g. time and fatigue).

## 2.4. General statistical considerations of the present research

Statistical considerations that are relevant throughout the present research are discussed here. Specific statistical considerations relevant to either Study 1, 2 or 3 are described in their corresponding chapters (Chapters 3, 4 and 5-7 respectively). However, issues regarding missing data and interpretation of effect size (ES) were relevant across the three studies. Therefore, the current section briefly discusses general methodological considerations of missing data (2.4.1.) and interpretation of effect sizes (2.4.2.) in relation to the present research.

### 2.4.1. Methodological considerations of missing data

This section briefly describes ways in which missing data were considered in the present research. First, missing data mechanisms are defined (2.4.1.1.). Subsequently, four main techniques for handling missing data are discussed in brief (2.4.1.1.). These techniques are listwise deletion, pairwise deletion, single imputation and multiple imputation (MI).

#### 2.4.1.1. Missing data mechanisms

There is no established cut-off point for an acceptable level of missing data (Dong & Peng, 2013). Missing data are sometimes cited as being acceptable at levels less than 5 percent (Tabachnick & Fidell, 2007) or 10 percent (Bennett, 2001) of a total dataset. It has been argued that more important than the quantity of missing data are the missing data mechanisms and patterns that impact the results of analysis (Tabachnick & Fidell, 2001). However, the more missing data, the greater risk of biased estimates. Therefore, caution must be taken when selecting an acceptable cut-off level for missing data. Data may be missing completely at random (MCAR), missing at random (MAR) or missing not at random (MNAR). When data are MCAR, there are no relationships between the missing data and other variables, either observed in the dataset or unobserved. Data that are MAR are related to observed variables, but not to unobserved variables. When data are neither MCAR nor MAR, they are specified as MNAR. Data that are MNAR are related to unobserved factors and not accounted for by observed variables. It can be difficult to ascertain whether missing data are MNAR, and violation of any of these assumptions can lead to biased parameter estimates and standard errors. Sensitivity analysis is a method of distinguishing between data that are assumed MCAR and data that are assumed MAR, through exploration of results under the two missing data assumptions (Resseguier, Giorgi, & Paoletti, 2011; Bennett, 2001).

#### 2.4.1.2. Techniques of handling missing data

There are three main traditional techniques for handling missing data. These are listwise deletion, pairwise deletion and single imputation. A fourth more recent approach is MI. The first traditional technique for handling missing data, listwise deletion, involves analysing only complete sets of data (i.e. complete

case analysis), resulting in analysis of a dataset with no missing data. When data are MCAR, listwise deletion can be an acceptable approach to use (Graham, 2009). However, it is rarely the case that researchers can be certain that data are MCAR (Azur, Stuart, Frangakis, & Leaf, 2011). Listwise deletion reduces sample size by deleting all cases with any missing values. This negatively affects statistical power and leads to difficulties in detecting small, but possibly important, relationships or effects between variables (Cox, McIntosh, Reason, & Terenzini, 2014). Furthermore, if the MCAR assumption is not met, listwise deletion may produce biased parameter estimates.

The second traditional technique of handling missing data is pairwise deletion, which also assumes data are MCAR. Missing values are removed and all complete data are used in analysis when calculating pairs of correlations across variables, thus, taking advantage of all available data. This allows sample size and power to be maximised. However, there is no agreement as to how standard errors are calculated. A common approach using the average sample size across analysis results in biased standard errors (i.e. over- or underestimation). The final traditional method of handling missing data is single imputation. Single imputation options include mean/median substitution, regression imputation, hot-deck imputation and 'last observation carried forward' (LOCF). The three techniques are discussed together because they result in the same problems when used to handle missing data.

Mean substitution replaces missing values with the mean of the variable in question. This allows the mean of the variable in question to remain unchanged, appearing advantageous for analysis relying solely on the mean (e.g. univariate analysis). However, this method changes relationships among variables and therefore is generally unsuitable for multivariate analysis. It is recommended that this option is never used (Cox et al., 2014; Tabachnick & Fidell, 2007; Pallant, 2007). Regression imputation creates a regression model that uses observed data from other cases to predict the value for missing data. LOCF, which is only used for longitudinal data, replaces missing data with the value of their last observed response. None of the three single imputation methods are suitable for conducting missing data analysis on the current dataset because they lead to biased parameter estimates in most situations and underestimated standard errors (Schafer & Graham, 2002). Furthermore, when used in

conjunction with correlational or regression analysis, they are known to overestimate covariances and thus, r squared (i.e. states that the regression model fits the data better than it actually does) (Cox et al., 2014; Graham, Cumsille, & Elek-Fisk, 2003).

There is no perfect solution for handling missing data, whatever the type of missing data are in a dataset (Cox et al., 2014). However, MI is a principled approach that offers considerable advantages over the traditional methods due to less restrictive assumptions and adjustment to precision. Unlike single imputation methods, it allows for preservation of all cases whilst retaining relationships among variables. SPSS (Statistical Package for the Social Sciences (analysis software from IBM) uses an iterative Markov chain Monte Carlo (MCMC) method known as fully conditional specification (FCS) or multiple imputation by chained equations (MICE). MI is based on the assumption that data is MAR, and uses completed values to create multiple predictions for missing values. A random error term is then drawn from parameter estimates and added to the predicted values. These become new values that are then used to predict the next set of predicted values. This is repeated a certain number of times (set to 10 iterations on SPSS) and a specified number of imputed datasets are created providing a range of plausible missing values. Imputation of three to five MI datasets has previously been considered sufficient (Schafer & Olsen, 1998). However, more recent recommendations suggest creating approximately as many imputed datasets as the percentage of missing data (White, Royston, & Wood, 2011).

### 2.4.2. Interpretation of effect sizes

The American Psychological Association (APA) stated the importance of effect sizes (ES) in the 5th edition of their publication manual by stating “it is almost always necessary to include some index of ES or strength of relationship in your results section … for the reader to fully understand the importance of your findings’’ (p. 25) (American Psychological Association, 2001). In the 14 years since then it has become increasingly more common for reporting of ES to be a requirement of scientific journals in the field of psychology (Ellis, 2010).

In psychological research, significance criterion is commonly set at .01, .05 or .10 to indicate the percentage of chance of rejecting the null hypothesis when it

is in fact correct (a Type 1 error). This criterion indicates a 5% chance of rejecting the null hypothesis when it is in fact correct (a Type 1 error). ES is based on the variance explained scale (r) and is related to the degree to which the null hypothesis is believed to be false. Reporting of ES has an advantage over the use of significance tests by providing a method of quantifying differences between two groups (Coe, 2002). To specify statistical significance in results sections of the present research, p values are provided. However, where appropriate, Cohen's d ES were calculated to provide information about the magnitude of the effect [*d* = (mean1 - mean 2) / pooled SD]. Interpretation of ES is based on Cohen's (1988) description of ≥ .8 as a large effect (8/10 of a standard deviation), ≥ .5 as a moderate effect (1/2 of a standard deviation), and ≥ .2 as a small effect (1/5 of a standard deviation). Therefore, if the means of two groups do not differ by ≥ 0.2 standard deviations, the difference is considered trivial even if statistically significant (Walker, 2010). Cohen (1988) set different interpretations of ES for explaining the difference between two means (*d*) and relationships between variables (r). Therefore, interpretation of effect size for correlational analyses was set at ≥ .10 for a small effect, ≥ .30 for a medium effect, and ≥ .50 for a large effect (Cohen, 1988).

Cohen's $U_3$ may be estimated to aid practical interpretation of Cohen's *d* ES by using corresponding z scores. For example, if *d* = .4 then z = .4, which corresponds to the 66th percentile. This would mean that 66 percent of one group would score above the mean of a comparison group (Cohen's $U_3$) and 84 percent of the two groups would overlap (overlapping coefficient). Additionally, there would be a 61 percent chance that a participant picked at random from the one group would have a higher score than a person picked at random from the comparison group (probability of superiority) (Magnusson, 2014). It is important to note that Cohen's $U_3$ estimates assume that the variable in question has an underlying normal distribution. Therefore, variables that do not fulfil this criterion are interpreted with caution when interpreting ES for Cohen's $U_3$ statistic.

Although the importance of interpreting research findings using ES is now relatively well recognised (Durlak, 2009), studies differ in their use of ES indicators (e.g. Cohen, 1988). Fern and Monroe (1996) have suggested that ES

is interpreted based on expected ES where this information is available from related research. This is more difficult for novel areas of research or pilot studies that may not have access to the relevant information to estimate expected ES. However, in the case of interventional research, a pilot study may provide estimated ES for all measures of interest (Moore, Carter, Nietert, & Stewart, 2011). Evidently, research context is important to consider when interpreting findings based on ES.

## Chapter summary

This chapter described methodological considerations deliberated throughout the research process. Quantitative methods were the focus of the three studies. However, qualitative methods were considered for use when they provided the most appropriate method of obtaining in-depth data where it was deemed essential to the research (e.g. in the initial stages of questionnaire development for Study 2). Measures that were taken to reduce the impact of bias relating to self-report questionnaires were described. For example, explaining anonymity and confidentiality of data to reduce social desirability biases, and assessing comprehension and interpretation of questionnaires using a pilot sample of individuals with CLBP. Furthermore, it was acknowledged that methodological considerations relating to the wider environment (e.g. the weather) may influence research findings through their effects on participants. Problems of definition and conceptual overlap of executive function processes were suggested to heighten psychometric concerns regarding executive function tasks. The resulting test battery took 45-60 minutes to administer, and included multiple measures and tasks that were selected based on psychometric integrity and low participant burden. Finally, statistical considerations regarding missing data and ES were discussed to provide context for the interpreting of findings from the present research. The next chapter presents Study 1: a systematic review investigating factors influencing adherence to home exercise in CLBP.

# 3. Study 1: Individual and Intervention-related Factors Associated with Adherence to Home Exercise in Chronic Low Back Pain: A Systematic Review.

This chapter discusses a published systematic review conducted to investigate factors influencing exercise adherence behaviour in chronic low back pain (CLBP) (Beinart et al., 2013). This chapter is written in the style of the published research article, whilst retaining the main formatting style of this thesis for purposes of clarity. The chapter begins with an abstract to briefly summarise each section of the systematic review, as per the published article (3.1.). Then, the area of non-adherence to prescribed home exercise in CLBP is briefly reiterated to provide rationale for conducting the systematic review (3.2.). Methods used to conduct the systematic review are described next (3.3.). This section focuses on quality assessment and statistical, clinical and methodological heterogeneity of studies identified by the review. The next section focuses on discussion of the results of the systematic review (3.4.). Finally, findings are discussed in relation to existing CLBP and MSK research and the findings of other systematic reviews (3.5.). Conclusions of the findings of the systematic review are presented in the last section (3.6.).

## 3.1. Abstract

*Background Context:* Adherence to exercise has been shown to reduce pain and increase function in patients with chronic low back pain. However up to 70 percent of patients are non-adherent to prescribed home exercise. Physiotherapists need to understand more about the complex factors influencing adherence to prescribed home exercise in order to tailor their exercise interventions more effectively and support patients to self-manage.

*Purpose:* This review identifies factors associated with adherence to healthcare provider prescribed home exercise in adults with CLBP.

*Study Design:* Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines were used for the reporting of this review.

*Patient Sample:* Literature investigating adherence to home exercise in adults with CLBP.

*Outcome Measures:* Adherence to home exercise was the primary outcome. Additional outcome measures were recorded in the data extraction table.

*Methods:* The following databases were searched: Embase, PsychINFO, Medline, PEDro, and the Cochrane Central Register of Controlled Trials. Data were independently extracted and assessed for methodological quality by two reviewers.

*Results:* Eleven randomised controlled trials (RCTs), including 1088 participants, met the inclusion criteria. Moderate evidence was found for one individual patient sub-factor and three intervention-related sub-factors associated with increased adherence to home exercise. These sub-factors were higher health locus of control, supervision, participation in an exercise programme, and participation in a general behaviour change programme (BCP) incorporating motivational strategies.

*Conclusions*: This is the first systematic review investigating adherence to prescribed home exercise in a chronic low back pain population. It is difficult to draw firm conclusions as research lacks detailed descriptions of intervention content. The utilisation of a taxonomy of behaviour change techniques has been suggested to overcome this key problem. This review has highlighted the lack of

standardised measures of adherence to prescribed home exercise. The development of a validated measure of adherence should be a priority as this will provide a better understanding of the multitude of factors that may influence adherence to home exercise.

## 3.2. Introduction

CLBP, defined as back pain lasting for at least three months (Koes, van Tulder, & Thomas, 2006), is a major cause of disability in Western populations (Descarreaux et al., 2002). Population estimates of the prevalence of CLBP are lacking, and reported estimates are varied (Juniper et al., 2009). Prevalence rates are reported to be 10.2 percent in the United States (Freburger et al., 2009); 10 percent in Australia (Walker, Muller, & Grant, 2004); and between 5.9 percent and 23 percent in Europe (Andersson, 1999; Juniper et al., 2009). A recent systematic review reported direct costs of back pain in Europe ranging from €187 million (Belgium) to €4236 million (Netherlands) and $90600 million in the United States (Dagenais, Caro, & Haldeman, 2008). Evidently, back pain remains a costly and challenging problem for the patient and society at large.

Guidelines state that CLBP patients should exercise and maintain a physically active lifestyle, therefore patients are typically prescribed home exercise programmes (NICE, 2009). Exercise programmes have been found to be moderately effective at reducing pain and improving function in CLBP (Hayden et al., 2005; van Middelkoop et al., 2011). Most effective treatments for CLBP consist of individually designed exercise programmes delivered in a supervised format, for example, home exercise with regular therapist follow-up (Hayden et al., 2005). Good adherence is necessary to improve the effectiveness of exercise programmes (World Health Organisation, 2003). Therefore, to ensure best clinical outcomes, factors associated with adherence to prescribed exercise in CLBP require further investigation.

Patients who adhere to prescribed exercise achieve a greater increase in physical function compared to poor adherers (Di Fabio, Mackey, & Holte, 1995). However, research shows that between 50 percent (Friedrich et al., 1998) and 70 percent (Harkapaa et al., 1991; Reilly et al., 1989) of patients with CLBP are non-adherent to prescribed home exercise. For the purposes of this review,

adherence is defined as “the extent to which a person’s behaviour .. corresponds with agreed recommendations from a healthcare provider” (McLean et al., 2010; World Health Organisation, 2003).

Previous reviews have investigated different types of adherence (for example, adherence to appointment attendance, in-clinic advice, or prescribed home exercise) in a general musculoskeletal (MSK) population (McLean et al., 2010; Jack et al., 2010; Jordan et al., 2010). However, it is important to note that factors associated with adherence might vary depending on the type of adherence being examined, as well as between people with different MSK pathologies. Different types of adherence and MSK pathologies are therefore better considered individually (Jack et al., 2010). Home exercise programmes are designed to encourage patients to remain active post-treatment. Long-term adherence to these programmes is important for patients to maintain lasting benefits (Friedrich et al., 2005). Factors associated with adherence to home exercise programmes require better understanding in order to develop effective interventions that encourage long-term self-management. For these reasons, the current systematic review focuses on identifying factors associated with adherence to healthcare provider (HCP) prescribed home exercise in adults with CLBP.

## 3.3. Methods

This section describes the search strategy used to identify relevant studies for the systematic review (3.3.1.). Inclusion and exclusion criteria for identified studies are stated (3.3.2.), followed by detailed information regarding data extraction and synthesis (3.3.3.). Quality assessment of selected studies is described in relation to a modified quality assessment tool (QAT) (3.3.4.). Subsequent to this, statistical, clinical and methodological heterogeneity of each study is discussed (3.3.5.).

### 3.3.1. Search strategy

The following databases were searched from their inception dates up to 18th January 2012: Embase, PsychINFO, Medline, PEDro, and the Cochrane Central Register of Controlled Trials. The following key words were used: ‘physical therapy’, ‘physiotherapy’, ‘adherence’, ‘patient compliance’, ‘non-

adherence', 'non-compliance', 'compliance', 'low back pain', 'lower back pain', 'chronic low back pain', 'chronic lower back pain', 'exercise', 'predictor', and 'barrier'. Internet searches of Google and Google Scholar were also conducted. The search method can be viewed in Figure 1. Two reviewers (first and second author) independently screened the titles, abstracts, and full articles of potentially relevant papers. Any discrepancies were discussed until agreement was reached. The primary outcome was adherence to home exercise prescribed by an HCP. Although the review is not confined to any specific measure for this outcome; a range of measures are expected to have been used, including any assessments of physical limitations, pain, or participation, using any scale or any standard questionnaire method.

**Figure 1.** ***Search method for identification of studies***

1. "Physical Therapy (Specialty)"/

2. physiotherapy.ti,ab.

3. physi* therapy.ti,ab.

4. 1 or 2 or 3

5. adherence.ti,ab.

6. Patient Compliance/

7. non-adherence.ti,ab.

8. non-compliance.ti,ab.

9. non adherence.ti,ab.

10. compliance.ti,ab.

11. 5 or 6 or 7 or 8 or 9 or 10

12. Low Back Pain/

13. low* back pain.ti,ab.

14. chronic low* back pain.ti,ab.

15. 12 or 13 or 14

16. exercise*.ti.ab

17. 4 and 11 and 15 and 16

18. predictor*.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, ps, rs, nm, an, ui, tc, id, tm]

19. barrier*.mp. [mp=ti, ab, sh, hw, tn, ot, dm, mf, dv, kw, ps, rs, nm, an, ui, tc, id, tm]

20. limit 16 to "all adult (19 plus years)"

21. limit 19 to all journals

22. limit 20 to English language

23. limit 21 to yr="1980 - current"

### 3.3.2. Inclusion and exclusion criteria

Studies were included if they investigated participants aged between 18 and 65 years; investigated patients with low back pain lasting at least three months; were published from 1980 to date; were published in the English language; and measured adherence to home exercise. All types of study design were acknowledged at this stage of the search process. Studies were excluded if they did not investigate adherence to prescribed home exercise; investigated patients managed primarily by drug therapy or multidisciplinary teams; investigated acute and/or sub-acute, together with chronic, low back pain; and investigated participants under 18 or over 65 years old. Studies investigating participants over 65 years old were excluded because adherence to exercise is likely to be influenced by multiple co-morbidities that become commonplace in this age group (Mailloux et al., 2006).

### 3.3.3. Data extraction and synthesis

Data were independently extracted by two reviewers (first and second author) using a standardised form. In addition to standard information about study population, attrition, interventions, outcome measures, and data analysis; the data extraction form included information about the following: treatment delivery, adherence as a primary or secondary outcome, additional treatment outcomes, measures of adherence and other outcomes, relationship between level of adherence and outcome if explored, baseline factors associated with adherence if explored, key adherence conclusions of the study authors, and details of any author correspondence. Extracted data can be found in Appendix 2. Findings were reported using p-values and phrasing from the original studies. Significant and non-significant outcomes were stated, together with times of follow-up for post-intervention results. The two reviewers extracted data from the articles as described in the section above and achieved 100 percent agreement.

### 3.3.4. Quality assessment

No valid and reliable quality assessment tool (QAT) was found to be suitable for the purposes of this review, therefore a modified 16-item tool was developed (Table 2). Ten of the 16 items were utilised from the 11-item van Tulder (van

Tulder, Furlan, Bombardier, & Bouter, 2003) QAT, as recommended by the Cochrane Back Review Group (Furlan, Pennick, Bombardier, & van Tulder, 2009). One item 'blinding of care provider' was excluded, as it is not applicable to physical therapy interventions (Liddle et al., 2004). Items from the van Tulder checklist were recorded in Table 2 and each study was awarded a score for both the modified QAT and the van Tulder QAT. This allowed for simple comparison of scores with previous reviews. This review however discusses quality assessment scores based on the modified QAT to allow for inclusion of additional important criteria not accounted for in the van Tulder QAT (e.g. adequacy of sample size, and validity and reliability of outcome measures). Further information about the modified QAT can be found in Appendix 3.

Each item on the 16-item QAT was scored either positive (1), negative (0), or unclear (0+). The van Tulder checklist considered trials to be of high (≥6/11) or low quality (≤5/11). However, in order to provide a more comprehensive description of methodological quality, this review categorised trials according to high (≥11/16), medium (6-10/16), and low quality (≤5/16) (24). The two reviewers piloted the QAT with four articles. This was followed by assessment of methodological quality of all included studies. Subsequently, six articles were randomly selected for independent assessment. There was 100% agreement between reviewers. Four articles were from the same two cohorts and were awarded one score based on all information from the two related publications (Friedrich et al., 1998; Friedrich et al., 2005; Soukup, Glomsrod, Lonn, Bo, & Larsen, 1999; Soukup, Lonn, Glomsrod, Bo, & Larsen, 2001).

## Table 2. *Quality assessment tool*

| | | |
|---|---|---|
| 1 | Was the assignment of subjects to treatment groups randomised appropriately? (SIGN) (van Tulder) | Yes / No / Unclear |
| 2 | Was an adequate concealment method is used? (SIGN) (van Tulder) | Yes / No / Unclear |
| 3 | Were subjects are kept 'blind' about treatment allocation? (SIGN) | Yes / No / Unclear |
| 4 | Were groups similar at baseline for the most important prognostic indicators? (Cochrane) (van Tulder) | Yes / No / Unclear |
| 5 | Were outcome assessors blinded about treatment allocation? (Cochrane) | Yes / No / Unclear |
| 6 | Was the drop-out described and acceptable? (van Tulder) | Yes / No / Unclear |
| 7 | Are reports of the study free of suggestion of selective outcome reporting? (Cochrane) | Yes / No / Unclear |
| 8 | Were co-interventions avoided or similar across groups? (Cochrane) | Yes / No / Unclear |
| 9 | Was compliance acceptable in all groups? (van Tulder) | Yes / No / Unclear |
| 10 | Did the analysis include an intention to treat analysis? (van Tulder) | Yes / No / Unclear |
| 11 | Were all relevant outcomes measured in a standard, valid and reliable way? (SIGN) | Yes / No / Unclear |
| 12 | Was the treatment protocol adequately described for the treatment and control groups (eg. frequency, intensity) (Maastricht) | Yes / No / Unclear |
| 13 | Was appropriate statistical analysis used? (Maastricht) | Yes / No / Unclear |
| 14 | Was a sample size calculation performed prior to initiation of the study? (Maastricht) | Yes / No / Unclear |
| 15 | Was the sample size adequate? (Bizzini) | Yes / No / Unclear |
| 16 | Was the timing of the outcome assessment in all groups similar? (van Tulder) | Yes / No / Unclear |

*Note:* 'Bizzini' - The Bizzini Scale; 'Cochrane' - Cochrane List for Methodological Quality Assessment; 'Maastricht' – The Maastricht list; 'SIGN' – Scottish Intercollegiate Guidelines Network checklist; 'van Tulder' – The van Tulder Scale.

### 3.3.5. Statistical, clinical and methodological heterogeneity

It was decided a priori that a quantitative summary may be used to provide information for statistical heterogeneity, for example, overall mean or odds ratio, if more than two studies were found to be homogeneous enough in term of clinical characteristics of the samples as well as similarity of the assessment of the outcome. However, this has not been the case. Clinical and methodological heterogeneity were found among the selected studies (see Table 3). Clinical heterogeneity refers to differences in patients' characteristics, for example, age and severity of pain before intervention. Methodological heterogeneity refers to variation in study design and outcome measures, duration of follow-up and statistical information provided. Clear differences were found in terms of entire sample size, size of intervention and control group; mean age of samples (where data were provided); duration of pain (where data were provided); length of intervention and number of treatment sessions; duration of follow-up; statistical information provided and variation in outcome measures used. For example, only two studies used the same outcome measure when assessing disability (The Oswestry Disability Index, Fairbank, Couper, Davies, & O'Brien, 1980; Donzelli et al., 2006; Kuukkanen, Malkia, Kautiainen, & Pohjolainen, 2007), of which one study used a non-validated Italian version (Donzelli et al., 2006). Other studies that assessed disability used the Greenough and Fraser Disability Questionnaire (Friedrich et al., 2005), The Low Back Pain Disability Index (Harkapaa et al., 1991) and the Roland-Morris Disability Questionnaire (RMDQ) (Vong, Cheing, Chan, So, & Chan, 2011).

**Table 3.** ***Sources of clinical and methodological heterogeneity***

| Clinical heterogeneity | | | | | | | | | | Methodological heterogeneity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Study** | **Sample size** | | | **Age (years)** | | | **Duration of pain (years)** | | | **No. of sessions & length of intervention** | **Duration of follow-up** | **Statistical tests** |
| | Entire | Final N I/vention | Final N Control | Entire (range & mean) | I/vention (mean) | Control (mean) | Entire | I/vention (mean) | Control (mean) | | | |
| Donzelli et al. (2006) | 53 | 21 | 22 | 20-65 ẋ=50 | * | * | * | * | * | 10 x 1 hr sessions & * | 3m & 6m | Descriptive statistics only |
| Ljunggren et al. (1997) | 153 | 62 | 64 | 18-65 (no ẋ) | 39 (SD 10.4) | 40.2 (SD 9.5) | * | * | * | 3 x per week for 12 months | 6,12,18,24,30,36,42 weeks | Descriptive statistics only |
| Friedrich et al. (1998; 2005) | 93 | 44 | 49 | 20-60 ẋ=44 | * | * | * | 4.22 (SD 4.09) | 3.8 (SD 3.65) | 10 x 25 min sessions over 4 or 5 weeks | 4m, 12m and 5 years | U statistic |
| Härkäpää et al. (1991) | 303 | 150 | 153 | 35-54 ẋ=45 | * | * | * | 14.6 (No SD) | 13.4 (No SD) | 15 x 2 hr sessions 2 x a week | | |

| Clinical heterogeneity | | | | | | | | | | Methodological heterogeneity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Study** | **Sample size** | | | **Age (years)** | | | **Duration of pain (years)** | | | **No. of sessions & length of intervention** | **Duration of follow-up** | **Statistical tests** |
| | Entire | Final N I/vention | Final N Control | Entire (range & mean) | I/vention (mean) | Control (mean) | Entire | I/vention (mean) | Control (mean) | | | |
| Soukup et al. (2001) | 77 | 39 | 38 | 18-50 (no ẋ) | 40.3 | 38.9 | * | 13 | 11.1 | 20 x 1 hr sessions over 13 weeks | 5m & 12m | ANOVA but no F statistic reported |
| Kuukkanen et al. (2007) | 60 | 29 | 28 | 31-49 | 41 (SD 8.1) | 40 (SD 8.9) | * | 11.1 (SD 8.8) | 10 (SD 7.7) | Daily home-exercise over 3m. | 3m, 6m, 12m, & 5 years | Descriptive statistics only |
| Linton et al. (1996) | 48 | 25 | 23 | ẋ=42 | * | * | * | * | * | 2 x 20m sessions over 20 weeks | 3m & 5m | T statistic |
| Reilly et al. (1989) | 40 | 20 | 20 | * | * | * | * | * | * | 96 sessions; 4 x a week over 6m | | |
| Vong et al. (2011) | 88 | 38 | 38 | 18-65 | 44.6 (SD 11.2) | 45.1 (SD10.7) | * | 3.5 (SD 4.7) | 4.25 (SD 6) | 10 x 30m sessions over 8 weeks | 4 week | F statistic |

*Note.* *Information not provided; Clinical heterogeneity refers to differences in patients' characteristics; Methodological heterogeneity refers to variation in study design, duration of follow-up or statistical information provided.

Testing formally for unobserved heterogeneity was felt to be inappropriate due to the differences in the interventions and outcomes, and also due to the differences between characteristics of the samples across studies. Therefore results were summarised qualitatively using a rating system for levels of evidence as used in previous reviews in this area (McLean et al., 2010; Jack et al., 2010; van Tulder et al., 2000). The rating system reported the following levels of evidence: strong, moderate, limited, conflicting, and no evidence. Table 4 provides definitions of these five levels of evidence.

**Table 4. Criteria used to establish levels of evidence.**

| Levels of evidence | Criteria |
|---|---|
| Strong | Consistent findings in at least 2 high quality RCTs. |
| Moderate | Findings from 1 high quality RCT or 2 or more low quality RCTs. |
| Limited | One low quality RCT. |
| Conflicting | Inconsistent findings among multiple RCTs. |
| No evidence | No studies found. |

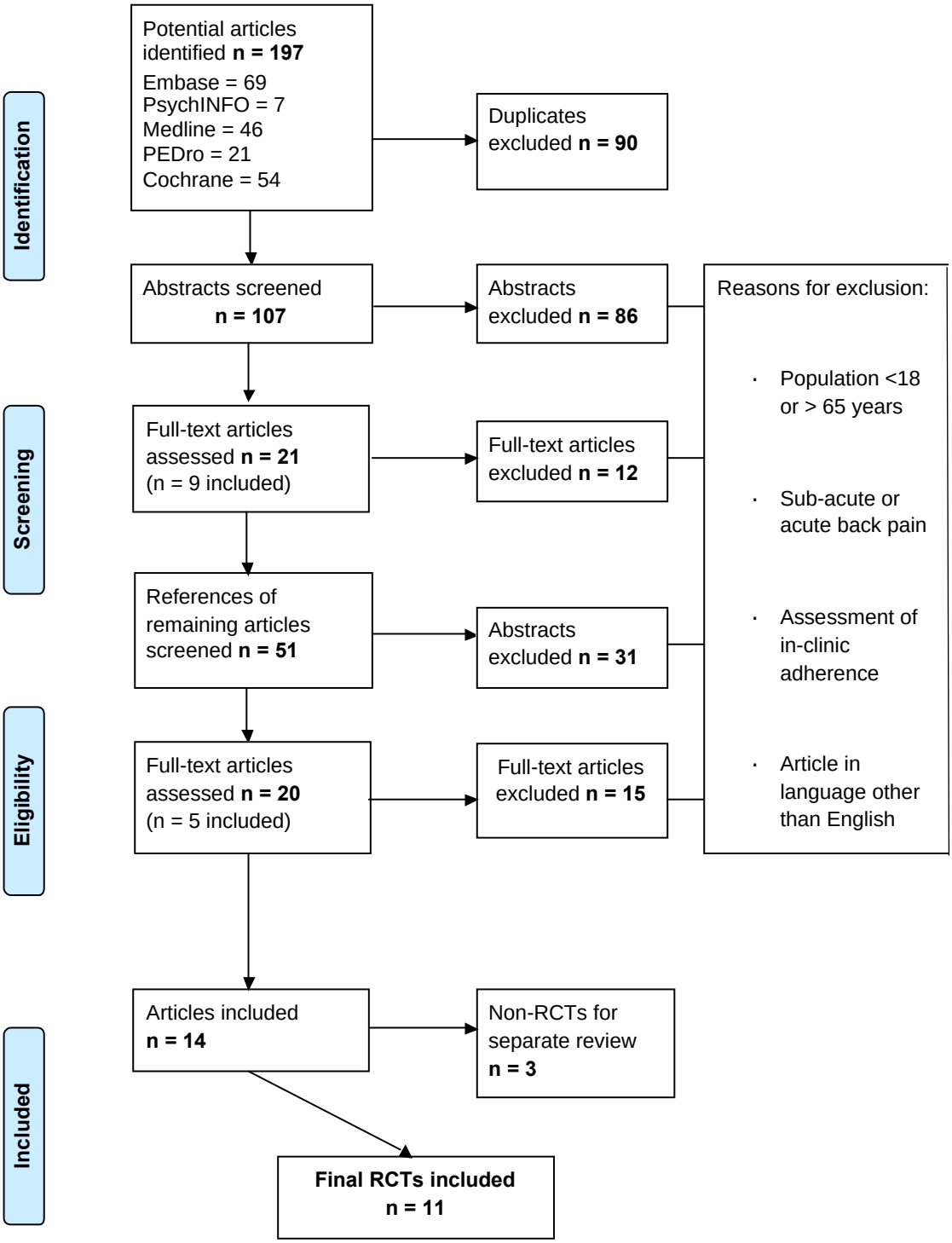
### 3.4. Results

This section discusses the selection process followed after the initial search for studies (3.4.1.). The results of the quality assessment are described next (3.4.2.). Subsequent to this, characteristics of identified studies are described (3.4.3.). The next section discusses factors that were found to be associated with adherence to prescribed home exercise (3.4.4.). Finally, further information regarding factors associated with adherence is described from three non-RCTs identified in the initial search (3.4.5.).

### 3.4.1. Selection process

The initial search identified 197 articles (Figure 2). After duplicates were removed, the remaining 107 titles and abstracts were screened. Eighty-six studies were excluded, and full texts of the remaining 21 articles were assessed for eligibility. At this stage there were disagreements about the potential inclusion of six articles. Following discussion amongst three of the reviewers (first, second and last author), three of these articles were included and three were excluded. A further nine articles were also excluded at this point. This resulted in 9 remaining articles. Main reasons for excluding trials are stated in Figure 2. References were screened to identify further relevant citations. Titles and abstracts of 51 potential studies were screened. Thirty-one articles were excluded. Full texts of the 20 remaining articles were assessed, resulting in the inclusion of another five articles. Of the remaining 14 articles, 11 were RCTs, and three were non-RCTs. Of the three non-RCTs, one study utilised a prospective, observational design, and the other two studies utilised a qualitative design. The three non-RCTs have been reported separately to allow for clear comparison of the 11 RCT's equivalent methodologies while providing a complete evaluation of all available research.

**Figure 2.** ***Flow diagram of selection process of studies using PRISMA guidelines***



### 3.4.2. Methodological quality

The results of the quality assessment can be found in Table 5. The reviewers agreed on 87 of the 96 items (90.6%) scored from the sampled six studies. The nine disagreements were due to reading errors or misinterpretation of the QAT criteria and were easily resolved. Quality assessment scores ranged from 5-12 out of 16. There was one low quality study (Ljunggren, Weber, Kogstad, Thom, & Kirkesola, 1997) six medium quality studies (Friedrich et al., 1998; Harkapaa et al., 1991; Friedrich et al., 2005; Reilly et al., 1989; Linton, Hellsing, & Bergstrom, 1996; Donzelli et al., 2006; Kuukkanen et al., 2007) and two high quality studies (Soukup et al., 1999; Soukup et al., 2001; Vong et al., 2011).

**Table 5.** ***Results of quality assessment***

| **Study** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **Final score** | **Van Tulder score** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *v/s | v/s | v/s | v/c | v/c | v | c | v/c | V | V | s | m | M | m | b | v | (out of 16) | (out of 10) |
| Vong (33) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0+ | 0+ | 1 | 12 (high) | 10 (high) |
| Soukup (25,26) | 1 | 0+ | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0+ | 1 | 1 | 1 | 1 | 1 | 11 (high) | 6 (high) |
| Friedrich (14,20) | 0+ | 0+ | 1 | 1 | 1 | 1 | 1 | 0+ | 1 | 1 | 0 | 1 | 1 | 0+ | 0+ | 1 | 10 (med) | 7 (high) |
| Kuukkanen (32) | 1 | 0+ | 0+ | 1 | 0+ | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0+ | 0+ | 1 | 9 (med) | 7 (high) |
| Reilly (29) | 0+ | 0+ | 0+ | 1 | 0+ | 1 | 1 | 1 | 1 | 1 | 0+ | 1 | 1 | 0+ | 0+ | 1 | 9 (med) | 6 (high) |
| Donzelli (31) | 0 | 0+ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0+ | 1 | 9 (med) | 7 (high) |
| Härkäpää (15) | 1 | 0+ | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0+ | 0+ | 1 | 8 (med) | 5 (low) |
| Linton (30) | 0+ | 0+ | 0 | 1 | 0+ | 1 | 1 | 1 | 0 | 0+ | 0 | 1 | 1 | 0+ | 0+ | 1 | 7 (med) | 4 (low) |
| Ljunggren (29) | 1 | 0+ | 0+ | 0 | 0+ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0+ | 0+ | 1 | 5 (low) | 4 (low) |

*Note:* *'b' – The Bizzini Scale; 'c' – Cochrane List for Methodological Quality Assessment; 'm' – The Maastricht list; 's' - Scottish Intercollegiate Guidelines Network checklist; 'v' – van Tulder Scale; 1 (yes); 0 (no); 0+ unclear.

### 3.4.3. Study characteristics

Eleven RCTs, ranging from 1989 to 2011, were included in this review. There were a total of 1088 participants between the ages of 18 and 65 years of age. Trials took place in the following countries: Italy (Donzelli et al., 2006); Norway (Soukup et al., 1999; Soukup et al., 2001; Ljunggren et al., 1997); Austria (Friedrich et al., 1998; Friedrich et al., 2005); Finland (Harkapaa et al., 1991; Kuukkanen et al., 2007); Sweden (Linton et al., 1996); North America (Mailloux et al., 2006); and Hong Kong (Vong et al., 2011). One study included an inpatient population, together with an outpatient population and a control group, however the inpatient data were not included in this review (Harkapaa et al., 1991). Length of studies, including follow-up, ranged from 3 months to 5 years. Harkapaa et al. (1991) and Vong et al. (2011) included three month follow-up; Reilly et al. (1989), Linton et al. (1996), and Donzelli et al. (2006) included six month follow-up; Ljunggren et al. (1997), Soukup et al. (1999) included 12 month follow-up; Soukup et al. (2001) included three year follow-up; and Friedrich et al. (2005) and Kuukkanen et al. (2007) included five year follow-up.

### 3.4.4. Factors associated with adherence

Eight main factors were found to be associated with adherence to home exercise. These factors were categorised into two groups: i) individual patient variables i.e. clinical and psychological factors and sub-factors (Table 6), and ii) intervention-related variables and their associated sub-factors i.e. participation in a BCP, type of exercise, developing a personal exercise programme, follow-up, supervision by a HCP, and participation in an exercise programme (Table 7). Table 6 includes measures used to test individual patient variables. Information regarding the effects of each intervention on adherence to home exercise were not reported so could not be included in Table 7. Significance levels were stated when inferential statistics were provided in the original study. When inferential statistics were not provided; descriptive statistics were stated. Tables 6 and 7 state the level of evidence associated with the factors found in each study. No factor was found to be strongly associated with adherence in this review. There was moderate evidence that the sub-factors higher health locus of control (N=569) (Harkapaa et al., 1991; Friedrich et al., 2005),

supervision (N=193) (28,29), participation in an exercise programme (N=613) (15,25,26,32), and the use of general BCP incorporating motivational strategies (N=267) (Friedrich et al., 1998; Friedrich et al., 2005; Linton et al., 1996) were associated with adherence to home exercise. There was limited evidence that the sub-factors higher motivation (N=93) (Friedrich et al., 1998; Friedrich et al., 2005), participation in development of an exercise programme (N=48) (Linton et al., 1996), having a low belief of the control of others over back pain (N=476) (Harkapaa et al., 1991), participating in a behavioural programme to enhance adherence (N=48) (Linton et al., 1996), use of positive reinforcement (N= 40) (Reilly et al., 1989), higher pain level at baseline (N=53) (Donzelli et al., 2006), higher disability at baseline (N=476) (Harkapaa et al., 1991), participation in a Pilates style programme (N=53) (Donzelli et al., 2006), and regular therapist follow-up (N=48) (Linton et al., 1996) were associated with adherence to home exercise. There was conflicting evidence that the sub-factors level of distress at baseline was associated with adherence to home exercise (N=569) (Friedrich et al., 1998; Harkapaa et al., 1991; Friedrich et al., 2005).

**Table 6.** ***Individual patient variables associated with adherence to prescribed home exercise***

| Individual patient variables | Level of evidence | Studies | Adherence a primary outcome* | Measures used to test individual variables | Results |
|---|---|---|---|---|---|
| ***Psychological sub-factors:*** | | | | | |
| Higher motivation | Limited | Friedrich et al. (1998; 2005) | Yes | Psychotherapy Motivation Questionnaire<br><br>(Schneider et al., 1989) | At 12 months, weekly training frequency in those with high motivation was significantly higher than in those with low motivation. (U = 396.5, *P* = 0.036). |
| Higher health locus of control | Moderate | Härkäpää et al. (1991) | Yes | Health Locus of Control Scale (Wallston et al., 1982) plus 2 items measuring beliefs in back pain control. | Patients with a higher health locus of control exercised significantly more than those with a weaker health locus of control at 3 month follow-up (OR = 1.96, *P* < 0.000). |
| | | Friedrich et al. (1998; 2005) | Yes | Subscale of the Psychotherapy Motivation Questionnaire (Schneider et al., 1989) | Patients with a higher health locus of control at 3.5 weeks did significantly more exercise at 4 months, compared to those with a lower health locus of control (r = 0.244, *P* = 0.043). |
| Lower control over back pain by others | Limited | Härkäpää et al. (1991) | Yes | Health Locus of Control Scale (Wallston et al., 1982) plus 2 items measuring beliefs in back pain control. | Patients with a stronger belief that others have control over their back pain exercised significantly less than those with a weaker belief at 3 month follow-up (OR = 0.75, *P* < 0.013). |

| Individual patient variables | Level of evidence | Studies | Adherence a primary outcome* | Measures used to test individual variables | Results |
|---|---|---|---|---|---|
| Lower distress | Conflicting | Härkäpää et al. (1991) | Yes | General Health Questionnaire (Banks et al., 1980) | Patients with lower distress levels demonstrated a significantly higher number of back exercises faultlessly at 3 month follow-up (OR = 0.53, *P* < 0.009). |
| Higher distress | Conflicting | Friedrich et al. (1998; 2005) | Yes | Subscale of the Psychotherapy Motivation Questionnaire<br><br>(Schneider et al., 1989) | Those with a higher level of distress at 3.5 weeks did significantly more exercise at 4 and 12 months, compared to those with lower distress at 3.5 weeks (4 months, r = 0.182, *P* = 0.036; 12 months, r = 0.194, *P* = 0.045). |
| ***Clinical sub-factors:*** | | | | | |
| Higher pain level | Limited | Donzelli et al. (2006) | Yes | 10cm Visual Analogue Scale for Pain | At 6 months, exercise was mainly performed when pain level had worsened. 62.8% of the total sample (61% of the Pilates and 50% of the back school control group) did more exercise when their pain levels had increased. (Only descriptive statistics were provided). |

| Individual patient variables | Level of evidence | Studies | Adherence a primary outcome* | Measures used to test individual variables | Results |
|---|---|---|---|---|---|
| Higher disability | Limited | Härkäpää et al. (1991) | Yes | The Low Back Pain Disability Index (Jarvikoski et al., 1986) | Patients in the experimental (outpatient) group with higher disability levels at baseline exercised more at 3 month follow-up compared to those with lower baseline disability levels (OR = 1.04, *P* < 0.031). |

*Adherence was considered a primary outcome if mentioned in the title or abstract, or if referred to as a primary outcome. PT (physiotherapy), BCP (behaviour change programme)

**Table 7.** ***Intervention-related variables associated with adherence to prescribed home exercise***

| Intervention-related variables | Level of evidence | Studies | Adherence a primary outcome* | Results |
|---|---|---|---|---|
| ***Participation in a BCP; sub-factors:*** | | | | |
| Positive reinforcement | Limited | Reilly et al. | Yes | Patients who received positive reinforcement plus supervised exercise did significantly more exercise than patients in the control group (independent exercise) at 6 month follow-up ($P < 0.01$). |
| BCP | Limited | Linton et al. | Yes | Patients in the intervention group (behaviour change programme plus advice to exercise) did significantly more strenuous exercise than the control group (advice to exercise) at 3 months (t = 1.89; $P = .033$); 5 months (t = 2.41; $P < .01$); and overall (t = 2.10; $P < =.03$). The intervention group also took part in significantly more general exercise activities at 6 months (t = 2.78; p < .005). |
| General BCP incorporating motivational strategies | Moderate | Vong et al. | No | Participation in a behaviour change programme, including motivational interviewing, was found to influence better adherence. Patients having PT plus motivational interviewing performed significantly more home exercise than those having PT alone at one month follow-up (F = 12.11, $P<.002$). |
| General BCP incorporating motivational strategies | Moderate | Friedrich et al. | Yes | At 12 months, weekly training frequency in the motivation group (incorporating general behaviour change techniques) was significantly higher than in the standard training PT group. (U = 396.5, $P = 0.036$) |

| Intervention-related variables | Level of evidence | Studies | Adherence a primary outcome* | Results |
|---|---|---|---|---|
| ***Type of exercise; sub-factors:*** | | | | |
| Pilates style | Limited | Donzelli et al. | Yes | At 6 month follow-up, more patients in the Pilates group (9.5%) performed regular home exercise compared to patients in the standard back class (4.5%). (Only descriptive statistics were provided). |
| ***Developing a personal exercise programme; sub-factors:*** | | | | |
| Participation in development of exercise programme. | Limited | Linton et al. | Yes | Patients in the intervention group (behavioural programme plus advice to exercise) were actively involved in developing their own exercise programme. Patients in the control group were asked to exercise twice a week for 20 minutes at a local health centre. Patients in the intervention group did significantly more exercise compared to the control (advice to exercise) over a period of 6 months (t = 2.10; *P* < =.03). |
| ***Follow-up; sub-factors:*** | | | | |
| Regular follow-up | Limited | Linton et al. | Yes | Patients in the intervention group (behavioural programme plus advice to exercise) had 2.5 hours of follow-up time (telephone and in person). The control group (advice to exercise) had no follow-up. Patients in the intervention group did significantly more exercise compared to the control group over a period of 6 months (t = 2.10; *P* < =.03). |

| Intervention-related variables | Level of evidence | Studies | Adherence a primary outcome* | Results |
|---|---|---|---|---|
| ***Supervision by a HCP; sub-factors:*** | | | | |
| Supervision | Moderate | Ljunggren et al. | Yes | Supervision was found to influence better adherence. 33% patients in the intervention group (home exercise using specialised equipment) and 35% of patients in the control group (standard PT) reduced home exercise at the end of a 12 month unsupervised period, prior to which they had participated in 12 months of supervised exercise. |
| Supervision | | Reilly et al. | Yes | Supervision was found to influence better adherence. Patients in the intervention group who participated in supervised exercise 4 times a week over 6 months, did significantly more home exercise compared to the control group who did independent home exercise. The supervised group completed a mean of 90.75 (SD 3.3) out of 96 home exercise sessions. The independent group completed a mean of 31.95 (SD 17.2) out of 96 sessions ($P < 0.01$). |
| Back school plus psychology and education (vs. control) | Moderate | Härkäpää et al. | Yes | Participation in a back school, incorporating psychology and education, was found to influence better adherence to home exercise. Patients in the intervention group exercised more frequently (OR = 0.51, $P < 0.037$) and showed better accomplishment of back exercises (OR = 0.16, $P < 0.000$) at 3 month follow-up (versus control group with written and oral instructions to exercise). |

| Intervention-related variables | Level of evidence | Studies | Adherence a primary outcome* | Results |
|---|---|---|---|---|
| ***Participation in an exercise programme; sub-factors:*** | | | | |
| Mensendieck exercise plus education programme (vs. baseline exercise) | | Soukup et al. | No | Participation in a Mensendieck exercise programme, including an educational component, was found to increase adherence. Patients in the intervention (Mensendieck) group did significantly more home exercise at 12 month follow-up compared to their baseline levels of exercise ($P <$ 0.05). Exercise levels in the control group (written and oral information) remained static from baseline to 12 month follow-up |
| Home exercise programme (vs. baseline exercise) | | Kuukkanen et al. | No | Participation in a home exercise programme was found to influence adherence at 1, 2, and 3 month follow-up. This paper only explored adherence to back exercises in the intervention group. Patients in the intervention group (home exercise programme) exercised an average of 3.5 sessions per week, for 49, 47, and 44 minutes per session, at 1 month, 2 month, and 3 month follow-up respectively. (No inferential statistics were provided). |

*Note:* *Adherence was considered a primary outcome if mentioned in the title or abstract, or if referred to as a primary outcome. PT (physiotherapy), BCP (behaviour change programme), HCP (healthcare provider)

### 3.4.5. Non-randomised controlled trials

Further information regarding factors associated with adherence was drawn from the three non-RCTs. Taimela, Diederich, Hubsch and Heinricy (2000) utilised a prospective, observational design with 125 CLBP patients. They reported that patients with significantly less pain at the end of 12 back classes ($F = 7.4$, $P = 0.008$) were more likely to continue exercising 14 months after the programme had ended. The other two studies utilised a qualitative design (Dean, Smith, Payne, & Weinman, 2005; Slade, Molloy, & Keating, 2009). Dean and colleagues (2005) explored nine patients' and eight physiotherapists' perceptions of adherence to exercise for CLBP. They identified lack of time to exercise as a frequent reason for poor adherence. Slade and colleagues (2009) explored exercise preferences in 18 patients with CLBP. They found that patients preferred exercises that matched their abilities and prior skills. When positive results were achieved early on in the programme, patients became more aware of the helpful and empowering skills of their physiotherapist. However, patients became frustrated if they felt that they were not being listened to and their symptoms became aggravated.

## 3.5. Discussion

This discussion begins with a summary of the main results of the systematic review (3.5.1.). Results are compared to findings from previous systematic reviews (3.5.2.). Subsequent to this, measurement of exercise adherence behaviour is discussed, with a focus on the lack of standardised measures of adherence behaviour in CLBP research (3.5.3.). Findings from non-RCTs are then briefly discussed to provide further understanding of factors associated with adherence behaviour in CLBP (3.5.4.). The next section describes implications of the findings of the present study (3.5.5.). This is followed by discussion regarding lack of detail in the reporting of BCPs by studies identified in the review (3.5.6.). Strengths and limitations of the systematic review are discussed next (3.5.7.). Finally, conclusions of the systematic review are presented (3.5.8.).

### 3.5.1. Summary of main results

Eight factors, and their related sub-factors, were found to be associated with adherence to prescribed home exercise. A summary of 11 RCTs (including 9 trials) found two high quality, six medium quality, and one low quality study. There was moderate evidence that one individual patient sub-factor, and three intervention-related sub-factors, were associated with better adherence. The individual patient sub-factor was higher health locus of control (Table 6). The intervention-related sub-factors were: i) supervision, ii) participation in an exercise programme, and iii) participation in a general BCP incorporating motivational strategies (Table 7). There was limited evidence for four individual patient sub-factors, and five intervention-related sub-factors (Tables 6 and 7). There was conflicting evidence that level of distress at baseline was associated with adherence (Table 6). The four moderate sub-factors are discussed below because they provided the highest levels of evidence found to be associated with adherence to home exercise.

### 3.5.2. Findings from previous reviews

To the authors' knowledge, this is the first systematic review to identify predictors of adherence to home exercise specifically in a chronic low back pain population. Previous systematic reviews investigating adherence to exercise have focused on a general MSK population (Jack et al., 2010; Jordan et al., 2010; McLean et al., 2010). Jack et al. (2010) examined barriers to treatment adherence in a mixed acute, sub-acute, and chronic MSK population. Similar to this review, they investigated adherence to exercise administered by a healthcare provider, rather than appointment attendance, or in-clinic adherence. The found strong evidence that poor adherence was associated with low self-efficacy, depression, anxiety, low social support/activity, low physical activity at baseline, helplessness, greater perceived barriers to exercise, and increase pain levels during exercise. McLean et al. (2010) reviewed interventions for enhancing adherence to exercise in an acute, sub-acute, and chronic MSK population. They examined attendance to appointments together with adherence to home exercise in five studies. Two of the five cohorts investigated CLBP, one of which was included in this review (Friedrich et al., 1998; Friedrich et al., 2005) and one that included older adults (>65 years) (Basler, Bertalanffy,

Quint, Wilke, & Wolf, 2007). With regards to adherence to home exercise, they found conflicting evidence that interventions increased short-term (<1 year) adherence. They found strong evidence that adherence strategies were not effective at increasing long-term (≥1 year) adherence. Jordan et al. (2010) reviewed interventions to improve adherence to exercise recommendations, and similarly to this review they investigated a chronic MSK population (pain lasting ≥3 months). They found 42 suitable studies, mainly examining osteoarthritis and spinal pain. Two of the 42 studies were also included in this review (Friedrich et al., 1998; Soukup et al., 1999). They concluded that supervised or individualised exercise therapy incorporating self-management techniques, may enhance adherence to exercise.

Although these reviews provide important insights into factors influencing adherence to exercise, it is important to remember that predictors of adherence to home exercise may vary between different MSK pathologies and types of adherence. Therefore, the results of these reviews are not entirely applicable to home exercise adherence in a CLBP population. This is partially due to the fact that all three reviews investigated mixed MSK populations. In addition to this, two reviews investigated acute and sub-acute pain (McLean et al., 2010; Jack et al., 2010) and one review investigated different types of adherence (McLean et al., 2010).

### 3.5.3. Measurement of adherence to prescribed home exercise

Similarly to Jack et al.'s (2010) systematic review, self-report diaries were found to be the most commonly used measure of adherence to home exercise. Poor completion rates for diaries, together with inaccurate recall and self-presentation bias, may affect the validity of data from these studies (Stone et al., 2003). It has been suggested that assessment of adherence may be improved with the use of physiotherapist-rated measures of adherence together with patient diaries (Shaw, Williams, & Chipchase, 2005). Additionally, electronic devices such as accelerometers and pedometers could be used (Bassett, 2003). However, electronic devices require the patient to use them systematically, and therefore might only be effective for patients who are likely to be adherent to other tasks, such as exercise. In addition, electronic devices may not be suitable for all types of prescribed home exercise as they primarily

measure activities of daily living (Yang & Hsu, 2010). Further, measuring adherence could be classed as an intervention in itself, meaning it is difficult to obtain an accurate measure of adherence (Haynes, Ackloo, Sahota, McDonald, & Yao, 2008). A standardised, validated measure of adherence should be used consistently in future studies (Jordan et al., 2010). However currently there is no standardised, validated measure of adherence to prescribed home exercise.

### 3.5.4. Non-randomised controlled trials

The three non-RCTs provided additional understanding of factors associated with adherence to home exercise. Taimela et al. (2000) found that lower pain at the end of treatment was associated with better adherence to home exercise 14 months after treatment. However, Donzelli et al. (2006) found the contrary, namely that higher pain levels were associated with adherence to home exercise six months after the end of treatment. Dean et al. (2005) concluded that an understanding of lower back pain as part of the normal aging process may help to facilitate patients' self-management of their pain. This, in turn, could aid the development of exercise as a habit, and lack of time might then become less of a reason for non-adherence. Slade et al. (2009) found that when positive results were achieved early on in the programme, patients became more aware of the helpful and empowering skills of their physiotherapist. However, patients became frustrated if they felt that they were not being listened to and their symptoms became aggravated. This suggests exercise programmes should be designed according to patient preferences and past exercise experiences, with an emphasis on tools that enhance patient-therapist communication.

### 3.5.5. Implications of findings

Both individual patient variables and intervention-related variables were found to influence adherence. The two sub-factors, higher health locus of control and participation in a general BCP incorporating motivational strategies, were components of psychology-based interventions. However, due to lack of description and definition of these interventions, it was difficult to deduce which components of the interventions influenced adherence. Therefore, it was deemed acceptable to categorise these sub-factors together under the term 'psychological interventions' for the purposes of discussion.

Supervision is necessary to check progress, discuss problems, and make amendments to an exercise programmes (Cohen & Rainville, 2002). In this review, supervision was found to increase adherence to home exercise in CLBP (Ljunggren et al., 1997; Reilly et al., 1989). This substantiates similar findings from previous studies and reviews (Jordan et al., 2010; Liddle et al., 2004; Bentsen, Lindgarde, & Manthorpe, 1997). Research is needed to explore the effects of different types of supervision (for example, individual or group supervision) and how these influence long-term adherence to home exercise in CLBP.

Participation in an exercise programme including prescribed home exercise increased adherence to home exercise (Harkapaa et al., 1991; Soukup et al., 1999; Soukup et al., 2001; Kuukkanen et al., 2007). However, it was difficult to determine which components of these exercise programmes influenced adherence. Slade et al. (2009) investigated CLBP patients' preferences about their exercise programmes. Patients expressed a desire to master exercises, and preferred exercises that matched their abilities. Effective communication and empowering skills from the healthcare provider, and financial and family support, were important factors that encouraged adherence to the exercise programmes. Further investigation of factors influencing engagement and participation in exercise programmes would increase understanding of which components may influence adherence.

Participation in a psychological intervention was associated with adherence to home exercise at 8 weeks and 12 weeks (Vong et al., 2011); 3 months (Harkapaa et al., 1991); and 12 months (Friedrich et al., 1998; Friedrich et al., 2005). Vong et al. (2011) concluded that a BCP incorporating motivational strategies increased confidence in the ability of the therapist, increased belief in the outcome of treatment, and increased trust in the therapist. Recent research suggests that MSK patients respond favourably to motivational interviewing (MI), and that MI is particularly useful for MSK practitioners attempting to facilitate behaviour change (Connelly & Ehrlich-Jones, 2010). However, motivational programmes vary across studies in terms of programme duration, training provider, and competency, making comparison across studies problematic (Chilton, Pires-Yfantouda, & Wylie, 2012).

Further research is required to clarify the use and acceptability of motivational strategies in the treatment of CLBP. In terms of clinical practice, it is important to consider the level of training a health care professional requires in order to competently deliver a motivational programme. Miller and Mount (2001) found that participation in a 1 to 3 day workshop was not effective in changing behaviour predictive of improved motivational outcome. A recent systematic review proposes that the most effective methods for training in MI include a combination of traditional workshops followed by extended coaching and clinical supervision (Chilton et al., 2012).

### 3.5.6. Problems with reporting of behaviour change programmes

The BCPs discussed in this review lacked detailed definitions and descriptions of the behavioural techniques used within interventions. The reporting of BCPs is generally poor, making inferences from interventions problematic (Michie, van Stralen, & West, 2011). It is probable that all of the intervention and control groups included some behaviour change techniques, as standard physical therapy aims to facilitate behaviour change. However, this information was not provided in the studies reported in this review. Future research should provide information about any training provided for the purposes of an intervention, together with definitions and detailed descriptions of behavioural techniques. In order to provide meaningful information about individual behavioural components, it is recommended that researchers utilise Michie et al.'s (2011) refined taxonomy of behaviour change techniques. This would allow for comparison of specific behavioural techniques across studies, providing evidence that is transferable to clinical training and practice.

### 3.5.7. Strengths and limitations

This is the first review investigating adherence to home exercise specifically in a CLBP population. A recent systematic review concluded that no QATs used in systematic reviews were reliable or valid for evaluating the methodological quality of RCTs in physical therapy research (Olivo et al., 2008). The development of a new QAT was deemed necessary as it allowed for the inclusion of additional important criteria that were found to be lacking in other QATs. However, this tool requires further reliability and validity testing.

A limitation of this review is that it is possible that some articles that may have provided further evidence of factors associated with adherence were overlooked. One reason for this may be because the term ‘concordance’ was not included in the search strategy. This term was used in two previous systematic reviews investigating exercise adherence behaviour in musculoskeletal samples (i.e. Jordan et al., 2010; Jack et al., 2010). The two reviews did not find any studies investigating adherence behaviour in CLBP in addition to those found in Study 1. However, studies published subsequent to the two reviews, and prior to Study 1, may have been overlooked in the present research.

A further limitation relating to the studies included in this review is that they were all RCTs; therefore the final comparisons were made using a t-test or ANOVA with the underlying assumption being that the two groups were similar with respect to the observed and unobserved characteristics. In reality however, this was not known, and none of the studies attempted to make adjustments for any of the factors that may have had an impact on the effectiveness of the intervention.

### 3.6. Conclusion

Lack of both RCTs and non-RCTs investigating adherence as a primary outcome meant that limited evidence was found for the majority of sub-factors. Moderate evidence was found for four sub-factors: higher health locus of control, supervision, participation in an exercise programme, and participation in a general BCP incorporating motivational strategies. However it is difficult to draw firm conclusions as a great deal of research lacks detailed descriptions of intervention content. The utilisation of a taxonomy of behaviour change techniques has been suggested in order to overcome this key problem (Abraham & Michie, 2008). This review has highlighted the lack of standardised measures of adherence to prescribed home exercise. The development of a validated measure of adherence should be a priority for the research community, as this may provide a better understanding of adherence to prescribed home exercise in CLBP.

## Chapter summary

This chapter described a systematic review conducted for Study 1 of the present research. The systematic review investigated individual and intervention-related factors associated with adherence to home exercise in CLBP. The systematic review found 11 RCTs that provided moderate evidence that one individual patient sub-factor, and three intervention-related sub-factors, were associated with better adherence behaviour. There was conflicting evidence that level of distress at baseline was associated with adherence behaviour. The systematic review found a lack of description of intervention content throughout identified studies. Furthermore, no studies used a validated measure to assess exercise adherence behaviour. The development and initial psychometric evaluation of a measure to assess adherence to prescribed home exercise is the focus of the next chapter.

# 4. Study 2: The Development and Initial Psychometric Evaluation of a Measure Assessing Adherence to Prescribed Exercise: the Exercise Adherence Rating Scale (EARS).

## 4.1. Overview

The lack of valid and reliable self-report measures of adherence to prescribed exercise demonstrates the necessity for a standardised, validated measure to be used consistently in future studies (Bollen et al., 2014; Beinart et al., 2013; Austin, Qu, & Shewchuk, 2012). The development of a valid measure is a priority as this may provide a better understanding of adherence to prescribed home exercise. Additionally, a measure such as this may provide a quick and simple way to assess adherence where self-report data is sufficient. It is anticipated that information provided from a measure such as this could aid the development of effective interventions that encourage long-term self-management of chronic low back pain (CLBP).

Accordingly, this chapter reports the development and initial psychometric evaluation of the first measure to assess adherence to prescribed home exercise in a CLBP sample: the Exercise Adherence Rating Scale (EARS). Firstly, methods followed in the initial stages of item development are described (4.2.). This section includes information regarding four stages of item generation, procedure, participant recruitment and plans of analyses. Secondly, results of analyses are discussed in terms of participant characteristics, reliability and validity analyses (4.3.). The next section discusses research and clinical implications of the EARS, strengths and limitations of the study and suggestions for future research (4.4.). Finally, conclusions of the study are presented (4.5.).

## 4.2. Method

This section discusses the four stages involved in initial item generation for the EARS (4.2.1.). Subsequent to this, discussion focuses on data collection, reliability and validity analyses (4.2.2.). This section includes description of sample size and participant recruitment (4.2.2.1.), procedure and measures used in the study (4.2.2.2.) and methods of statistical analyses (4.2.2.3.).

### 4.2.1. Phase I: Item generation and scoring

There were four stages of item generation which generated a total of 17 items (see Table 8). The first stage involved a focus group including individuals with CLBP and physiotherapists. In order to recruit individuals with CLBP for the focus group, an advert was placed on the 'Backcare' website (www.backcare.org.uk) and newsletter (Appendix 21). Travel expenses were reimbursed (up to £20). The two physiotherapists were recruited during a brief (approximately 5 minute) presentation at Guy's and St. Thomas' (GSTT) physiotherapy department. This presentation described the studies developed for this thesis and physiotherapists were asked if they would be willing to partake in a focus group for the present study.

The second stage involved consultation with two physiotherapists and two health psychologists regarding additional items that may not been obtained in the previous stage of item generation. The third stage was based on consideration of previous research including the systematic review of the CLBP home exercise adherence literature (Study 1, Chapter 3) (Beinart et al., 2013). The final stage involved consultation with experts regarding existing, psychometrically evaluated, measures of medication adherence behaviour. From the latter, the Medication Adherence Rating Scale (MARS; 10 item) (Horne, 1997) was selected to assess any areas of adherence not already established as important in the previous stages of item generation. The MARS was selected over other measures of medication adherence behaviour because it has shown good psychometric properties across chronic illness samples (Lavsa, Holzworth, & Ansani, 2010). Furthermore, the MARS included items that assessed both medication adherence behaviour and identified reasons associated with adherence behaviour. Therefore, it was believed that the MARS included a range of items that may provide additional information not found in the preceding three stages of item generation. Four of the 10 MARS items were found to be capable of assessing both medication and exercise adherence and these were amended to relate to exercise behaviour (items 14-17 on Table 8).

The first stage resulted in the generation of 15 items (items 1-15 on Table 8). Item 12 was a result of both the focus group and a health psychologist from the second stage of item generation. Item 13 resulted from both the focus group

and the systematic review. Items 14 and 15 were informed by both the focus group and the MARS. The MARS alone informed items 16 and 17.

**Table 8.** ***Seventeen core questionnaire items for the exercise adherence rating scale***

| | |
|---|---|
| 1 I do my exercises as often as recommended | FG |
| 2 I adjust the way I do my exercises to suit myself | FG |
| 3 I don't get around to doing my exercises | FG |
| 4 Other commitments prevent me from doing my exercises | FG |
| 5 I feel confident about doing my exercises | FG |
| 6 I don't have time to do my exercises | FG |
| 7 I'm not sure how to do my exercises | FG |
| 8 I do some, but not all, of my exercises | FG |
| 9 I don't do my exercises when I am tired | FG |
| 10 I do less exercise than recommended by my healthcare professional | FG |
| 11 I fit my exercises into my regular routine | FG |
| 12 I do my exercises because I enjoy them | FG, C |
| 13 My family and friends encourage me to do my exercises | FG, PR |
| 14 I stop doing my exercises when my pain is worse | FG, MARS |
| 15 I forget to do my exercises | FG, MARS |
| 16 I do my exercises to improve my health | MARS |
| 17 I continue doing my exercises when my pain is better | MARS |

*Note*: *FG (focus group), C (consultation with physiotherapists and health psychologists), PR (previous research), MARS (Medication Adherence Rating Scale). The items in Table 8 are numbered in relation to the associated text for purposes of clarity. Items were ordered differently for data collection.*

Separate to the 17 core questionnaire items, preliminary questions were included to obtain information regarding an individual's exercise prescription (Prescribed Exercise Questionnaire; PEQ) (Appendix 4a). A further five tick-box questions were developed to extract further information about the type, intensity and duration of prescribed exercise, together with two questions providing additional information about self-reported adherence to the prescribed home exercise. These two questions assessed prescribed exercise behaviour and actual exercise behaviour. It was expected that the two questions may provide

additional information regarding adherence behaviour for later validation of the EARS.

An open-ended free text response question was included at the end of the PEQ allowing individuals to provide qualitative information about their adherence behaviours. The question stated: 'In your own words, please can you explain why you have, or have not, done your exercises?' This qualitative information was reviewed throughout the development process to ensure that the 17 original questionnaire items adequately covered adherence and non-adherence to prescribed home exercise. No additional information was procured from the qualitative data and therefore no further items were added or excluded from the questionnaire at this time. A pilot sample of 20 individuals with chronic low back pain completed the 17-item EARS prior to the main study. This resulted in the removal of item 17 (I continue doing my exercises when my pain is better) and the rewording of item 16, both due to lack of clarity. Item 16 originally stated "I do my exercises to reduce my health problem" and was reworded to state "I do my exercises to improve my health". The 16 remaining items were scored using a 5-point Likert scale (0 = completely agree to 4 = completely disagree) with a possible summed score range from 0 to 64. After reverse scoring six positively phrased items, a higher score indicated better adherence to exercise.

### 4.2.2. Phase II: Data collection, validity, and reliability analyses

This section describes sample size and participant recruitment for the study (4.2.2.1). Subsequent to this, procedure and measures used in the study are described (4.2.2.2.). Results of validity and reliability analyses are presented in the next section (4.2.2.3.).

#### 4.2.2.1. Sample size and participant recruitment

There is no clear consensus for the minimum sample size for conducting exploratory factor analysis (EFA) (Kline, 2013). The target sample size was set at 150 as this was feasible and in line with recommendations for a minimum of between five and 10 participants per item (Kline, 2013; Gorsuch, 1983). Participants were recruited from physiotherapist-led chronic back pain rehabilitation classes at GSTT and King's College Hospital's (KCH) in London, UK. Participants attended a triage session with a physiotherapist prior to referral

into six, 1.5 hour, weekly back classes. Classes consisted of 45 minutes of exercise followed by 45 minutes of education (including basic information about anatomy and physiology, pacing and dealing with flare ups). Eligible patients who were willing to participate were recruited. Inclusion and exclusion criteria were as follows:

Inclusion criteria:

- CLBP of 12 weeks of more; with or without leg symptoms.
- 18 years or older.
- Participation as a treatment patient for non-specific CLBP in Physiotherapy Departments at GSTT Hospitals, or King's College Hospital.
- Prescription for home exercises.
- Fluent in written and spoken English.

Exclusion criteria:

- Unable or unwilling to give consent.
- Having LBP of 12 weeks of more due to pregnancy.
- Having LBP that is attributable to a recognisable, known specific pathology (e.g. infection, tumour, osteoporosis, fracture, structural deformity, inflammatory disorder (e.g. ankylosing spondylitis), radicular syndrome or cauda equina syndrome.
- Having neurological, psychiatric or intellectual disturbances, such as, presence of head injury, stroke, dementia, major depression, psychiatric illness, epilepsy, drug abuse or alcohol abuse.

Initially 446 patients were approached and 168 (37.6%) agreed to participate. Eighteen participants were excluded from the analysis due to incomplete measures. These participants were either non-contactable (n=7), stopped attending back classes due to referral for spinal surgery (*n* = 2) or hydrotherapy (*n* = 5), could not complete the study due to illness (n=3) or chose not to complete the study due to time constraints (n=1). This resulted in a final sample of 150 participants, sub-samples of which also completed baseline data for measures of pain and disability and test-retest data.

#### 4.2.2.2. Procedure and measures

Patients were approached in the waiting room and given an information sheet describing the study prior to their first back class. Those who were willing and eligible to participate completed a consent form, a demographic form and measures of self-report disability and pain. The demographic form assessed age, gender, BMI, ethnicity, education and employment status (Appendix 8). A sub-sample of the 150 participants also completed baseline measures of pain (present pain intensity from the Short-form McGill Pain Questionnaire; n = 61) (SF-MPQ, Melzack, 1987) and disability (Roland-Morris Disability Questionnaire; n = 72) (RMDQ, Roland & Morris, 1983) at this point in order to further validate the EARS. Present pain intensity is assessed by the SF-MPQ using a visual analogue scale (VAS) from 'no pain' (score of 1) to 'worst possible pain' (score of 10). A higher score indicates higher pain. When completing the RMDQ, participants are asked to tick any of the 24 statements that apply to them with each tick providing a score of 1. Participants can score from 0 to 24, with a higher score providing evidence of higher disability. The RMDQ and SF-MPQ are described in detail in the protocol for Study 3 (Chapter 5, Section 5.5.2.). Relationships were expected between baseline clinical factors and subsequent adherence behaviour. However, due to the paucity of research in this area (Beinart et al., 2013), there were no *a priori* hypotheses regarding the direction of these in the present study.

Six weeks after baseline testing, participants were contacted in person after their final back class, or via telephone if they did not attend their final class, to complete the EARS. Thirty of the 150 participants were contacted via telephone 3 weeks after this (at 9 weeks) in order to complete the EARS for a second time to provide test-retest data. This was considered a suitable length of time for adherence behaviour to remain stable, whilst avoiding any 'carry-over effects' due to memory and practice (Allen & Yen, 2002). Ethical approval was obtained from Dulwich Research Ethics Committee (10/H0808/9).

#### 4.2.2.3. Statistical analyses

Prior to analyses, data were screened and assumptions of normality were tested. Frequencies and descriptive statistics (means and SDs) were performed

on the data. A combination of visual inspection (e.g. histograms and bar charts) and assessment using skewness and kurtosis were used to assess normality. Values of skewness and kurtosis between -2 and +2 were considered acceptable (George, 2010). Pearson product-moment correlation coefficients were used to investigate relationships between the 16 initial EARS items.

Construct validity was explored using an exploratory categorical data factor analysis (EFA), which, for a one factor solution, is equivalent to a 2 parameter graded item response theory model (Samejima, 1969). Analyses were conducted using FACTOR software (Lorenzo-Seva & Ferrando, 2006). Prior to performing the EFA, suitability of the item pool for factor analysis was assessed. EFA was computed from polychoric correlation matrices, rather than Pearson correlation matrices, as the EARS utilises an ordinal rather than interval scale. Factor extraction used the unweighted least squares estimator.

Three methods were used in order to decide the number of factors to be retained. Kaiser's criterion (the eigenvalue rule) (Kaiser, 1974), Catell's scree test (1966) and parallel analysis (Horn, 1965; Timmerman & Lorenzo-Seva, 2011). The first two approaches are the most commonly used in studies employing EFA (Costello & Osborne, 2011). However these methods have been argued to overestimate the number of factors necessary to retain (Reise, Waller, & Comrey, 2000; Pallant, 2010). A growing body of research maintains that parallel analysis (PA) is a better method for factor retention in EFA (Kline, 2013; Reise et al., 2000; Patil, Singh, Mishra, & Todd Donavan, 2008; Dinno, 2009). It was deemed best practice to compare all three methods to ensure that the optimal number of factors was retained. An item was assigned to a factor if its factor loading was greater than 0.30 (Lorenzo-Seva & Ferrando, 2006).

Criterion validity was assessed by correlating total EARS score with prescribed and actual exercise behaviour as reported by each participant. Participants were asked to state prescribed exercise behaviour: 'for how long have you been asked to continue doing these exercises?' and actual exercise behaviour: 'how often are you doing these exercises?' There were five possible answers to the two questions: a) every day, b) 4 to 6 days a week, c) 2 to 3 days a week, d) 1 day a week and e) not at all. The two questions were scored from 4 (every day) to 0 (not at all). Difference scores were calculated by subtracting one score from

another, with a smaller difference indicating better adherence. For example, if prescribed exercise behaviour resulted in a score of 4 (exercise every day) and actual exercise behaviour resulted in a score of 4 (exercising every day), the difference score would be zero.

Pearson correlations were used to investigate relationships between total EARS scores and difference scores for prescribed and actual exercise behaviour. A higher score on the EARS indicates better adherence. Furthermore, a smaller difference score indicates better adherence. Therefore, a significant, negative correlation was necessary to demonstrate evidence of criterion validity. Criterion validity was further investigated by correlating scores for retained factors with scores on measures of pain (SF-MPQ) and disability (RMDQ) using a sub-sample of n=72 and n=61 respectively. Pearson correlations were calculated to assess the strength and directionality of the relationships between EARS factors and pain and disability.

Internal consistency was estimated by Cronbach's alpha. Reliability coefficients greater than 0.70 were deemed as acceptable. To further assess reliability, the total information function for each factor, which indicates the precision of the scale (i.e. reliability) across the range of the latent construct, was calculated from the discrimination and difficulty parameters of the item response parameterisation of the model. This is more useful than Cronbach's alpha, which implies constant reliability across the range of the latent construct. The information function is particularly useful in determining whether a tool might be useful as a screening tool since reliability would need to be high for high levels of the latent construct (e.g. high non-adherence). Intraclass correlation coefficients (ICC) based on two-way random effects were calculated to assess the 3 week test-retest reliability of the EARS.

A content analysis was planned of qualitative data arising from the open-ended question in the PEQ. This data provides further information regarding explanations of exercise adherence behaviour that may be useful for further development of the EARS. Five stages of conventional content analysis were followed as described by Hsieh and Shannon (2005): a) familiarisation with the data, b) generation of preliminary codes from the data, c) examining codes and

combining or sub-categorising them where appropriate, d) reviewing codes and e) finalising codes.

## 4.3. Results

This section discusses the results of validity and reliability analyses. Firstly, participant characteristics are described (4.3.1.). Secondly, descriptive statistics focus on the distribution of scores among the data (4.3.2.). Subsequent to this, results of validity analyses are described (4.3.3.). This section includes discussion of construct validity (4.3.3.1.) and criterion validity (4.3.3.2.). Results of reliability analyses are the focus of the next section (4.3.4.). Correlational analysis of items not suitable for EFA is then presented to provide additional information regarding explanations for exercise adherence behaviour in the present CLBP sample (4.3.5.). Finally, further explanations for exercise adherence behaviour in the present CLBP sample are provided in response to the open-ended question at the end of the PEQ (4.3.6.).

### 4.3.1. Participant characteristics

This section describes participant characteristics for the focus group (4.3.1.1.) and for the main study (4.3.1.2.).

#### 4.3.1.1. Focus group

Recruitment for the focus group resulted in eight individuals with CLBP and two physiotherapists. Mean age for the eight CLBP participants was 45 years (range 32 – 64 years; SD 10.4). Six of the eight participants (75%) were female and seven were from any white background (one participant was Caribbean British). Five participants (63%) had GCSE or A-levels and three (38%) were of university or graduate level. Four participants (50%) were employed, two were unemployed (25%) and two were retired (25%). The two physiotherapists that participated in the focus group were both female and of any white background. One physiotherapists held a Masters level degree in physiotherapy and the other held a university level qualification. Both physiotherapists were employed at Guy's Hospital.

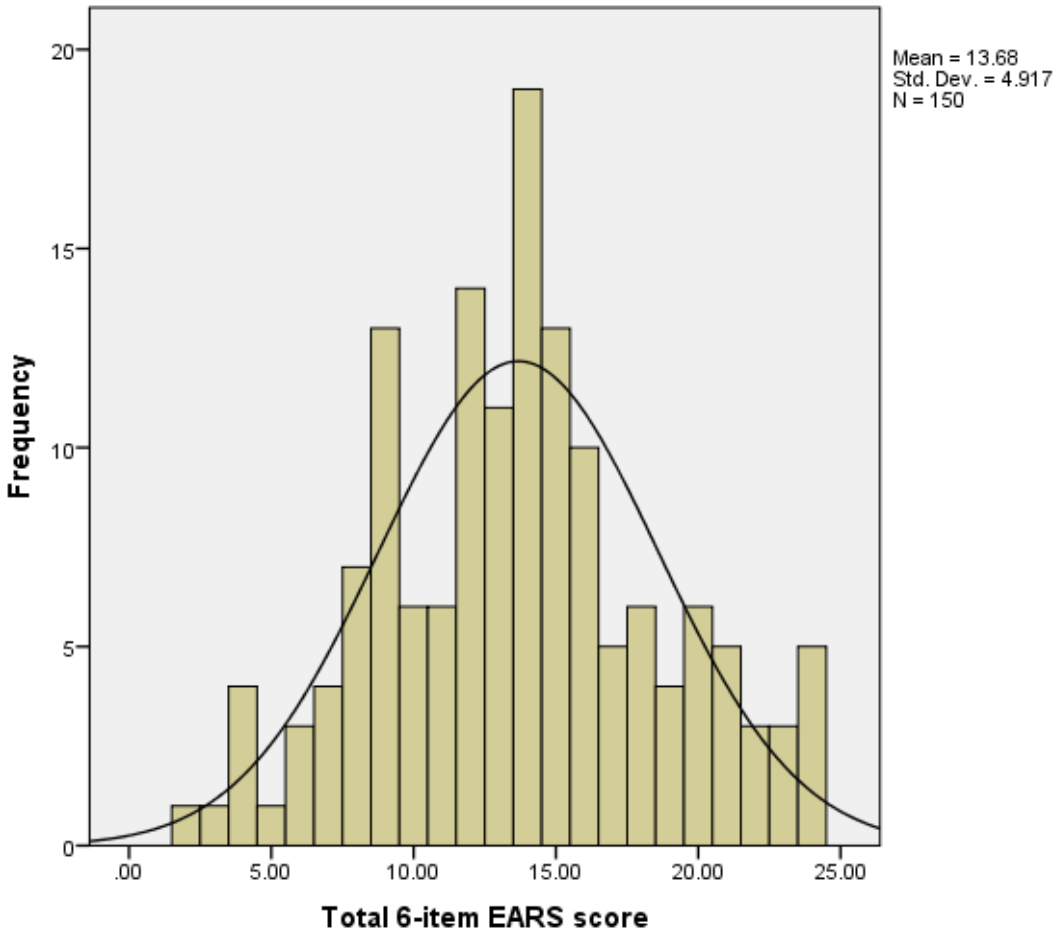
#### 4.3.1.2. Main study

One hundred and fifty participants completed baseline demographic data. Mean sample age was 49.5 years (range 24 – 79; SD 13.3) and 59.3 percent were female. Forty-two percent of participants were from any white background, 36 percent were African or Caribbean British, 10 percent were Asian or Asian British and 12 percent were from mixed backgrounds. Twenty percent of participants had received no formal education, 35 percent had GCSE or A-levels and 45 percent were of university or graduate level. Fifty-nine percent of the sample were employed, 19 percent were unemployed, 20 percent were retired and 2 percent were students. Mean disability score (RMDQ) was 9.6 (SD 5.6) (n=72) and mean present pain intensity score (SF-MPQ) was 5.3 (SD 2.3) (n=61).

### 4.3.2. Descriptive statistics

The histogram in Figure 3 shows no obvious deviations from normality for the 6-item EARS data. Skewness (.10) and kurtosis (-.31) were well within the acceptable ranges of -2 and +2. Therefore, EARS data were deemed normally distributed and suitable for further analyses.

**Figure 3:** ***Histogram displaying distribution of EARS scores***




Bar charts were created to show distribution of scores for the initial 16 EARS items (Figures 4 and 5). Items are divided into two figures for purposes of clarity. Figure 4 displays six of the 16 items that were reverse scored in order for a higher score to indicate better adherence. After reverse scoring, scores for each of these six items range from 0 (completely disagree) to 4 (completely agree).

**Figure 4.** ***Bar charts displaying distribution of scores for 6 reverse scored EARS items***

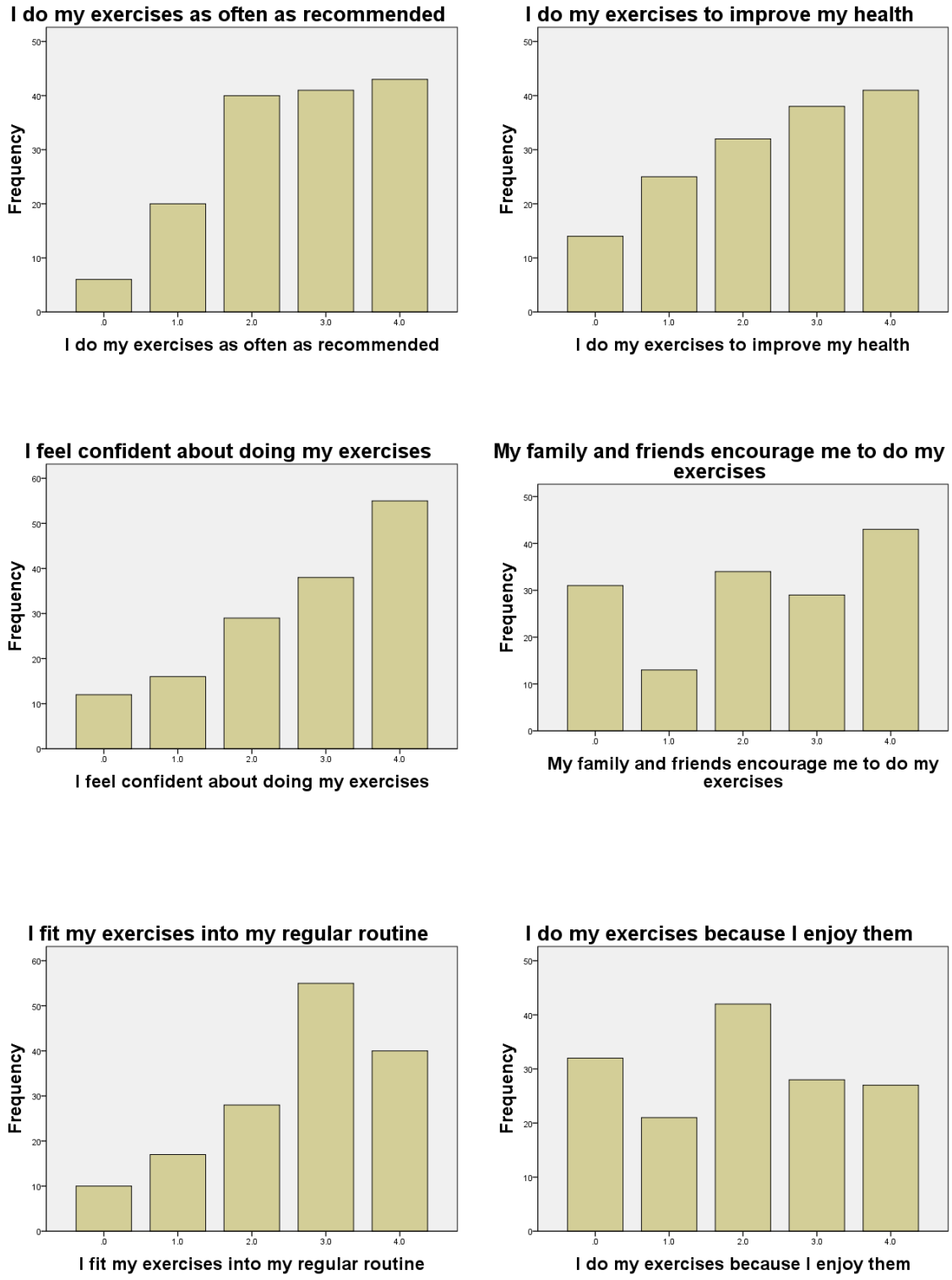
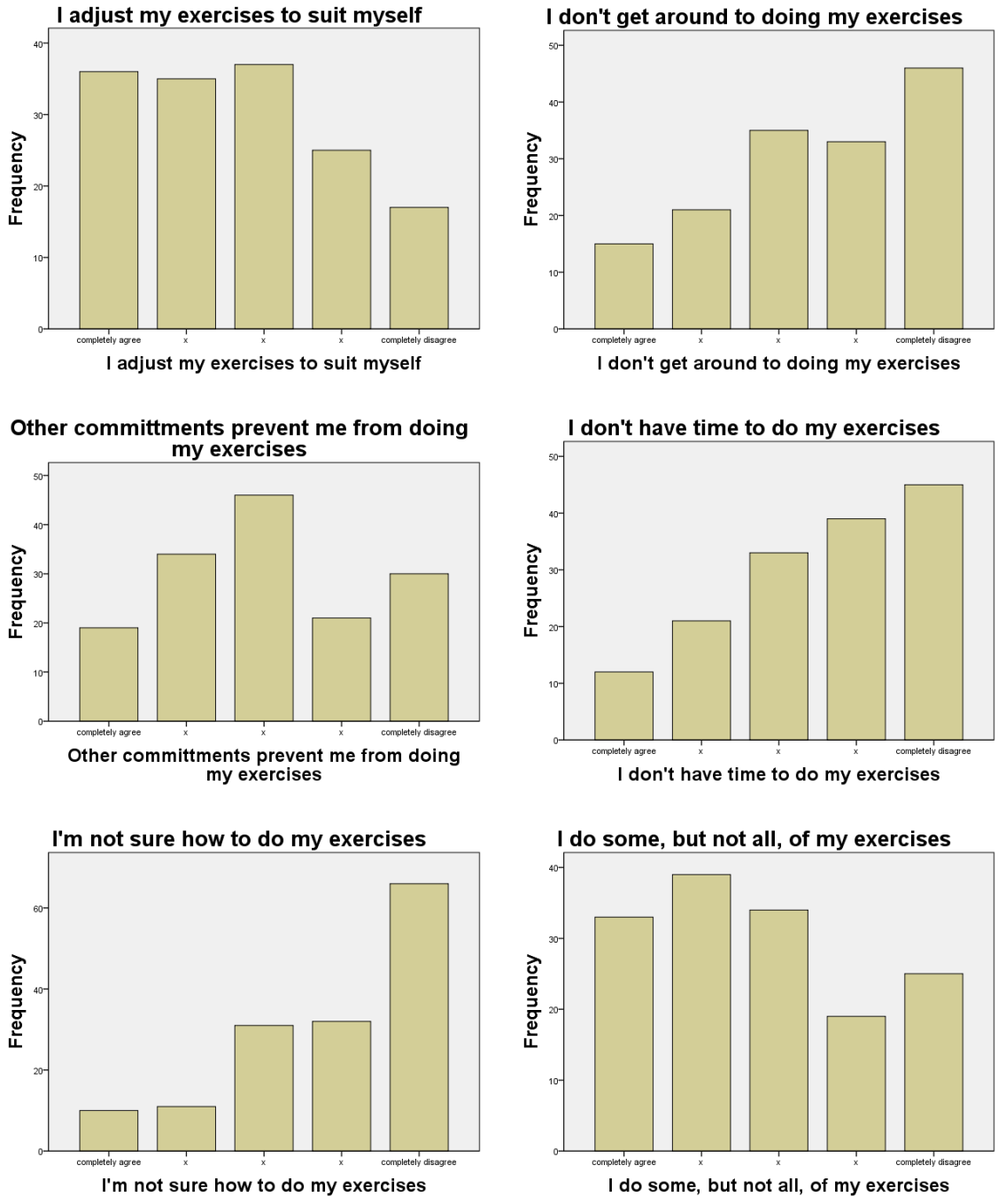



Figure 4 shows that between 40 and 55 (out of 150) participants stated better adherence behaviour (i.e. a score of 4) when asked if they do exercises as

often as recommended, if they do exercises to improve their health, if they feel confident doing their exercises and if their family and friends encourage them to do their exercises. When asked if they fit their exercises into their regular routine and if they exercise because they enjoy it, between 40 and 55 participants were moderately adherent (i.e. scored 2 or 3). Scores were relatively evenly distributed across the two items relating to family and friends and exercising for enjoyment. Furthermore, all items display the full range of possible answers.

Figure 5 displays the distribution of ten of the 16 initial EARS items that did not require reverse scoring. In contrast to the previous bar charts, scoring for the 10 items ranges from 0 (completely agree) to 4 (completely disagree). A higher score indicates better adherence.

**Figure 5.** ***Bar charts displaying distribution of scores for 10 of the initial 16 EARS items***



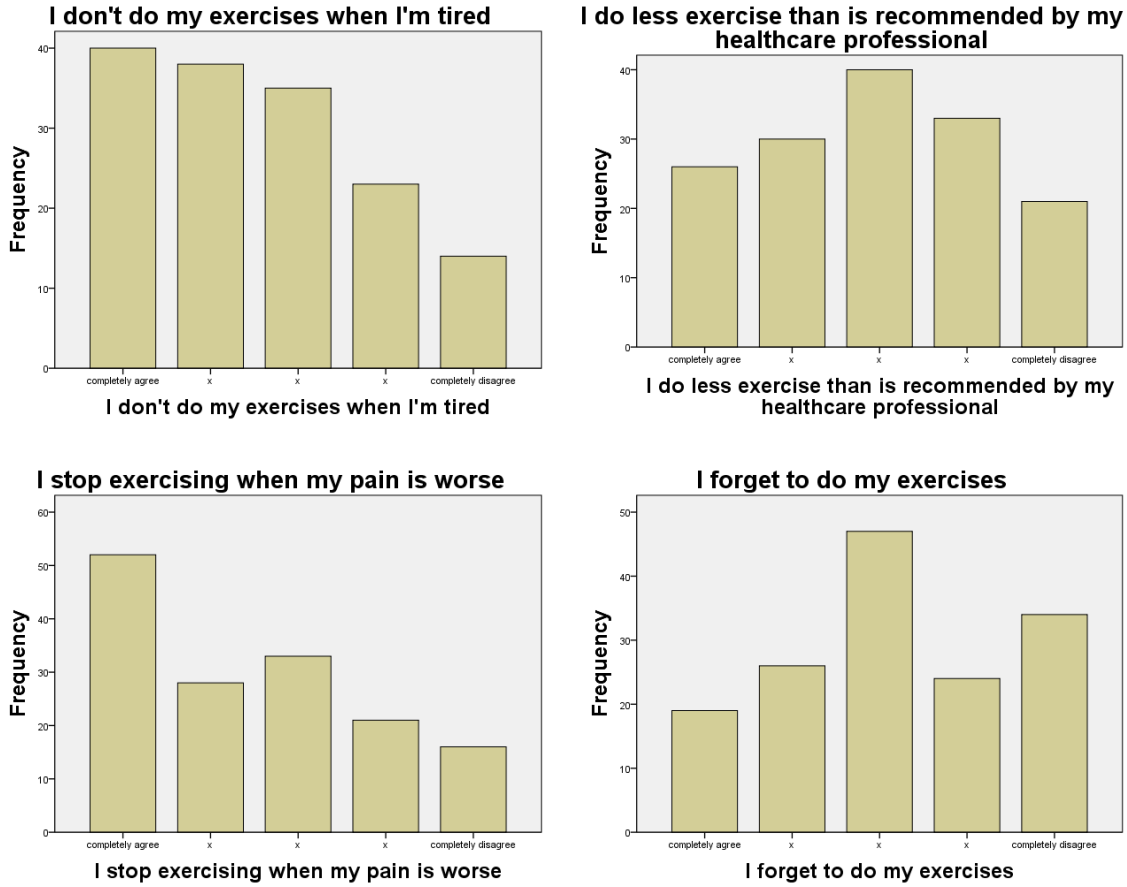



Figure 5 shows that participants who were less adherent (i.e. score of 0) to prescribed exercises were more likely to adjust exercises to suit themselves and to do some, but not all, of their exercises (approximately n=35). These participants were also less likely to exercise due to tiredness (n=40) and pain (n=50). A small number of participants (approximately n=15-20) were less adherent due to time constraints, other commitments, not being sure how to do their exercises and forgetting to exercise. Furthermore, all items display the full range of possible answers.

Relationships between the 16 initial EARS items were investigated using Pearson correlations (Table 9). The 16 EARS items are labelled by number in the table due to space constraints. Numbers refer to the following items:

| | |
|---|---|
| EARS 1 | I do my exercises as often as recommended |
| EARS 2 | I adjust my exercises to suit myself |
| EARS 3 | I stop exercising when my pain is worse |
| EARS 4 | I forget to do my exercises |
| EARS 5 | I feel confident about doing my exercises |
| EARS 6 | I don't have time to do my exercises |
| EARS 7 | I'm not sure how to do my exercises |
| EARS 8 | My family and friends encourage me to do my exercises |
| EARS 9 | I don't do my exercises when I'm tired |
| EARS 10 | I do less exercise than is recommended by my healthcare professional |
| EARS 11 | I fit my exercises into my regular routine |
| EARS 12 | I don't get around to doing my exercises |
| EARS 13 | I do some, but not all, of my exercises |
| EARS 14 | Other commitments prevent me from doing my exercises |
| EARS 15 | I do my exercises to improve my health |
| EARS 16 | I do my exercises because I enjoy them |

**Table 9.** ***Correlations between 16 initial EARS items*** *p<.05. **p<.01.

| **Variable** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EARS 1 | 1 | | | | | | | | | | | | | | | |
| EARS 2 | -.203* | 1 | | | | | | | | | | | | | | |
| EARS 3 | -.077 | .197* | 1 | | | | | | | | | | | | | |
| EARS 4 | .250* | .117 | .369** | 1 | | | | | | | | | | | | |
| EARS 5 | .381* | -.166* | -.016 | .055 | 1 | | | | | | | | | | | |
| EARS 6 | .385** | .052 | .128 | .500** | .142 | 1 | | | | | | | | | | |
| EARS 7 | .244** | .023 | -.004 | .252** | .483** | .390** | 1 | | | | | | | | | |
| EARS 8 | .267** | -.284** | -.023 | -.071 | .262** | .095 | .108 | 1 | | | | | | | | |
| EARS 9 | .147 | .153 | .254** | .220** | -.044 | .182* | .023 | -.057 | 1 | | | | | | | |
| EARS 10 | .304** | .149 | .058 | .242** | .093 | .240** | .210* | .080 | .297** | 1 | | | | | | |
| EARS 11 | .440** | -.102 | .073 | .219** | .299** | .219** | .257** | .172* | .034 | .147 | 1 | | | | | |
| EARS 12 | .340 | -.048 | .103 | .410** | .213** | .401** | .439** | .199* | .122 | .338** | .273** | 1 | | | | |
| EARS 13 | .288** | .251** | .182* | .289** | -.054 | .239** | .157 | .035 | .284** | .397** | .184* | .320** | 1 | | | |
| EARS 14 | .362** | -.040 | .007 | .340** | .204** | .435** | .347** | .159 | .165* | .237** | .316** | .604** | .261** | 1 | | |
| EARS 15 | .294** | -.022 | .050 | -.084 | .232* | .083 | .069 | .136 | .144 | .072 | .319** | .116 | .042 | .123 | 1 | |
| EARS 16 | .358** | -.151 | .072 | .131 | .304* | .258** | .230** | .101 | .183** | .078 | .407** | .097 | .093 | .214** | .344* | 1 |

Table 9 shows a range of effect sizes (ESs) from r = .007 (EARS 14 and EARS 3) to r = .604 (EARS 14 and EARS 12). Many of the statistically significant relationships between items display moderate ESs (i.e. r ≥ .3). However, strong effects (r ≥ .5) are shown between two pairs of items: a) EARS 6 (time) and 4 (forgetting) and b) EARS 14 (commitments) and 12 (some, not all, exercises). In addition to this, two pairs of items display virtually no relationship (i.e. r < .01): a) EARS 7 (not sure how to do exercises) and 3 (stop when pain is worse) and b) EARS 14 (commitments) and 3. Each of the 16 items is significantly correlated (i.e. p<.05 or p<.01) with multiple remaining items. This suggests that many of the 16 items may be measuring dimensions of a similar construct. Investigation of construct validity investigates this further.

### 4.3.3. Tests of validity

The first section describes exploratory factor analysis (EFA) used to investigate construct validity of the EARS (4.3.3.1.). The second section describes correlational analyses used to investigate criterion validity (4.3.3.2.).

#### 4.3.3.1. Construct validity

Inspection of the polychoric correlation matrices revealed the presence of many coefficients of .3 and above. Considering all 16 items together, the overall Kaiser-Meyer-Olkin value was .69, exceeding the recommended minimum value of .60 (Kaiser, 1974). However, the individual values for several of the items assessing reasons for non-adherence were below .60. As a result, items were separated for further analyses into the 6-items relating to adherence behaviours and 10 items relating to reasons for adherence and non-adherence. The Kaiser-Meyer-Olkin value was .81 for the 6-items relating to adherence behaviours with all individual items values >.75, supporting the factorability of the correlation matrix. However, the overall Kaiser-Meyer-Olkin value was <.6 for the 10 items relating to reasons for adherence and non-adherence, therefore it was not found to be suitable for EFA. The main analyses were performed on the 6-item data only.

EFA of the 6-items assessing adherence behaviours revealed the presence of one factor with an eigenvalue exceeding 1. The scree-plot, parallel analysis and eigenvalue rule all suggested that one factor should be extracted. Item means,

factor loadings and item response parameters are shown in Table 10. All items loaded strongly loaded on the factor, which explained 66% of the common item variance between items. The value for *a* is the discrimination parameter. The discrimination parameter demonstrates how effectively each item can discriminate between exercise adherence behaviour at either end of a continuum. Similar to the interpretation of the factor loadings, higher values for *a* indicate a stronger association between the item and the latent construct. The smaller the value of *a*, the less it is related to the construct of adherence behaviour. For example, the item 'I fit my exercises into my regular routine' displays the poorest relationship with adherence behaviour (*a* = .55). Whereas, the item 'I don't get around to doing my exercises' displays the strongest relationship with adherence behaviour (*a* = .95).

Item difficulty is reflected by the difficulty parameters *(d* values). Since the EARS has five response levels (strongly disagree to strongly agree), Item Response Theory (IRT) analysis provides four difficulty parameters (*d*1 to *d4*). These indicate the level of adherence behaviour necessary for 50 percent of individuals to endorse that item. For example, for the item 'I do my exercises as often as recommended, *d*1 is -2.73. This indicates that 50 percent of people scoring 2.7 standard deviations below the mean of the latent trait (i.e. adherence behaviour) endorse this item. Whereas, for *d*4 (.98), 50 percent of people scoring just under 1 standard deviation below the mean on the latent trait endorse this item. The mainly negative difficulty parameters for this item indicate that this item functions best for individuals with poorer exercise adherence behaviour. This is also the case for the two items 'I fit my exercises into my regular routine' and 'I don't get around to doing my exercises'. The remaining three items appear to function equally as well for individuals across the exercise adherence behaviour continuum. The 10 items relating to reasons for adherence and non-adherence were not suitable for factor analysis. However, they are provided for use as single-item scales where additional information is required about adherence behaviours (Appendix 4c).

**Table 10.** ***Factor loadings and parameter estimates for the 6-item exercise adherence rating scale (N = 150).***

| | **Mean** | **SD** | **Factor Loading** | **Discrimination Parameter** | **Difficulty Parameters** | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | *a* | *d*1 | *d*2 | *d*3 | *d*4 |
| I do my exercises as often as recommended * | 2.6 | 1.2 | 0.59 | 0.74 | -2.73 | -1.47 | -0.20 | 0.98 |
| I forget to do my exercises | 2.2 | 1.3 | 0.56 | 0.68 | -2.029 | -0.93 | 0.51 | 1.33 |
| I do less exercise than recommended by my healthcare professional | 1.9 | 1.3 | 0.57 | 0.69 | -1.64 | -0.56 | 0.62 | 1.87 |
| I fit my exercises into my regular routine * | 2.7 | 1.2 | 0.49 | 0.55 | -2.95 | -1.76 | -0.60 | 1.32 |
| I don’t get around to doing my exercises | 2.5 | 1.3 | 0.69 | 0.95 | -.1.80 | -0.97 | -0.06 | 0.77 |
| I do some, but not all, of my exercises | 1.8 | 1.4 | 0.56 | 0.67 | -1.40 | -0.12 | 0.94 | 1.72 |

*Note:* *reverse scored items

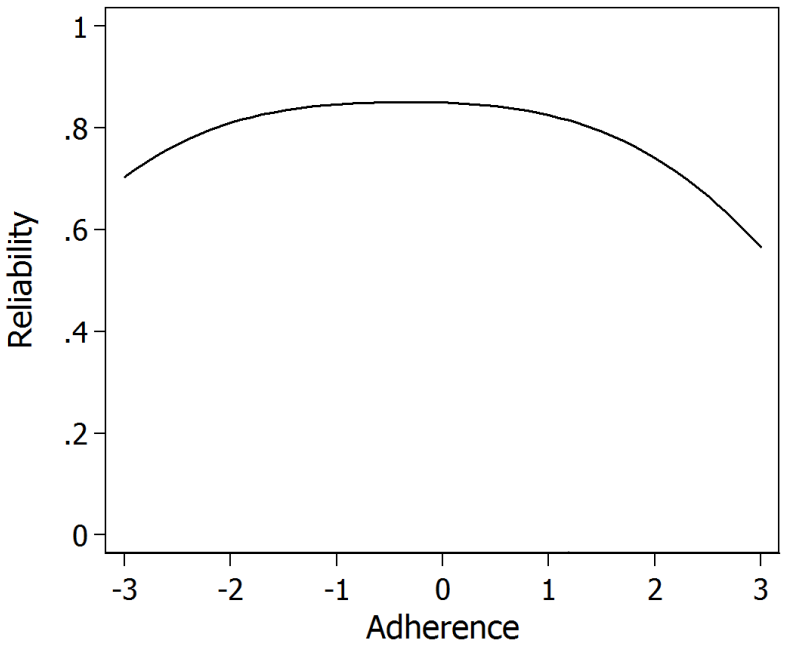
#### 4.3.3.2. Criterion validity

Pearson correlations were used to investigate relationships between total 6-item EARS scores and difference scores for prescribed and actual exercise behaviour. A significant, negative correlation displayed a moderate ES between total EARS scores and difference scores (prescribed exercise behaviour – actual exercise behaviour) ($r = -.312$, $p < .001$). This correlation provided initial evidence of criterion validity for the 6-item EARS. Criterion validity was further examined by correlating baseline present pain intensity (SF-MPQ) and disability (RMDQ) scores with total 6-item EARS score. Correlations between disability and the 6-item EARS demonstrated a very small, negative ES ($r=-.058$, $p>.05$). Correlations between present pain intensity and 6-item EARS demonstrated a small, positive ES ($r=.112$, $p>.05$). These findings indicate that lower baseline disability and higher baseline pain are weakly related to subsequent adherence to prescribed homes exercises. However, these relationships are not significant in the present CLBP sample. Results of criterion validity analyses are mixed and suggest that the EARS requires more investigation in this area.

### 4.3.4. Tests of reliability

Internal consistency was found to be acceptable for the single factor ($\alpha = 0.758$). Figure 6 shows the reliability of the EARS in measuring the latent construct (adherence behaviour) across the distribution of the construct, calculated from the total information function.

**Figure 6.** ***Local reliability for the factor 'exercise adherence' on a standardised scale***




The IRT reliability function indicates relatively high reliability across most of the range of the construct, although it drops off for higher levels of adherence. Since the tool is designed to measure non-adherence this is unlikely to be an issue. The EARS appears to provide reliable (> 0.7) scores between -1 and 1 standard deviation for both factors. This indicates that it is a good general measure that will discriminate well between people within the normal range of adherence. A sub-sample of 30 participants were re-assessed after a 3 week period to establish test-retest reliability for the EARS. Test-retest reliability in a sub-group of 30 participants assessed after 3 weeks was high [ICC = 0.97 (0.94 – 0.98)], indicating excellent reliability.

### 4.3.5. Summary for 10 items relating to reasons for non-adherence

The Kaiser-Meyer-Olkin value for the 10 items relating to reasons for non-adherence was <.6. Therefore, the 10 items were not suitable for EFA. The 10 items were correlated with a total score for adherence behaviour (i.e. the 6-items) as a further means of validating the EARS as a measure of adherence (Table 11). This shows the relative strength of each item in explaining non-adherence. Mean scores and standard deviations of the 10 items relating to reasons for non-adherence are also shown in Table 11.

**Table 11.** ***Descriptive data and correlations for 10 items relating to reasons for non-adherence.***

| 10 items relating to reasons for adherence behaviour | Mean | SD | Adherence |
|---|---|---|---|
| 1. I don't have time to exercise | 2.6 | 1.3 | .514** |
| 2. Other commitments prevent me from doing my exercises | 2.1 | 1.3 | .549** |
| 3. I'm too tired to do my exercises | 1.6 | 1.3 | .292** |
| 4. I feel confident about doing my exercises | 2.7 | 1.3 | -.243** |
| 5. My family and friends encourage me to do my exercises | 2.7 | 1.5 | -.169* |
| 6. I do my exercises to improve my health | 2.5 | 1.3 | -.185* |
| 7. I do my exercises because I enjoy them | 2.0 | 1.4 | -.289** |
| 8. I adjust the way I do my exercises to suit myself | 1.7 | 1.3 | .056 |
| 9. I stop exercising when my pain is worse | 1.5 | 1.4 | .192* |
| 10. I'm not sure how to do my exercises | 2.9 | 1.2 | .404** |

*Note:* *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed). Items 4, 5, 6 and 7 require reverse scoring so that a higher score indicates better adherence.

Strong, positive correlations displaying large ES were found between item 1 (I don't have time to exercise), item 2 (other commitments prevent me from doing my exercises) and adherence (item 1: r=.514, p<.001; item 2: r=.549, p<.001). Stronger disagreement (i.e. a higher score) with both statements was associated with better adherence. A positive correlation displaying a moderate ES was found between item 10 (I'm not sure how to do my exercises) and adherence (r=.404, p<.001). Positive correlations displaying small ESs were

found between item 3 (I'm too tired to do my exercises), item 8 (I adjust the way I do my exercises to suit myself), item 9 (I stop exercising when my pain is worse) and adherence (item 3: r=.292, p<.001; item 8: r=.056, n.s; item 9: r=.192, p<.05). Negative correlations displaying a small ES were found between item 4 (I feel confident about doing my exercises), item 5 (my family and friends encourage me to do my exercises), item 6 (I do my exercises to improve my health), item 7 (I do my exercises because I enjoy them) and adherence (item 4: r=-.243, p<.001; item 5: r=-.169, p<.05; item 6: r=-.185, p<.05; item 7: r=-.289, p<.001).

These results suggest that participants were less likely to adhere to prescribed home exercise due to lack of time, other commitments and not being sure how to perform their exercises. They were more likely to adhere due to confidence in performing their exercises and due to enjoyment of exercise. Information regarding explanations of adherence behaviour may be useful indications of areas that require individual-level intervention to improve adherence to prescribed home exercise as assessed by the 6-item EARS.

### 4.3.6. Explanations for exercise adherence behaviour

This section discusses qualitative data from an open-ended question participants were asked prior to completing the EARS questionnaire. This item was 'In your own words, please can you explain why you have, or have not, done your exercises?" Qualitative data from the open-ended item can be found in Appendix 22. Thirty-seven out of the 150 participants in the present study chose to answer this question. Data were transcribed and content analysis was used to analyse the data (Table 12). Firstly, the researcher became familiarised with the data by reading it multiple times. Secondly, 13 preliminary codes were generated based on recurring patterns within the data (e.g. exercising to reduce pain or exercising to reduce disability). Thirdly, the 13 preliminary codes were grouped under six higher-order codes. The six higher-order codes were: a) exercising to improve health and function (H&F), b) exercising to reduce the impact of CLBP (Imp.), c) practical barriers to non-adherence (Prac.), d) physical and mental barriers to non-adherence (P&M), e) barriers directly related to exercise (Exer.), and f) treatment-related facilitators (Tr.). Fourthly, all codes were reviewed by an independent researcher. Lastly, codes were

finalised into two meaningful groups using two overarching codes (adherence and non-adherence) to help explain the data in relation to adherence behaviours. Table 12 displays an example of a quote for each of the 13 explanations alongside the related code and number of participants using each explanation.

**Table 12.** ***Qualitative data explaining reasons for adherence and non-adherence***

| Explanations of Exercise Adherence Behaviour | Example quote | Number of participants |
|---|---|---|
| **Adherence** | | |
| To reduce pain (Imp.) | 'I do the exercises because I want to stop feeling pain and discomfort' (P7) | 4 |
| To reduce disability (Imp.) | 'I try as I know they help my back feel like it has more movement' (P103) | 2 |
| Back health is a priority (H&F) | 'I continue to do my exercise …. despite being very busy' (P43) | 1 |
| Happiness/enjoyment (H&F) | 'I actually quite like doing them' (P116) | 1 |
| Feedback (Tr.) | 'When I had feedback, I did it' (P2) | 1 |
| **Non-adherence** | | |
| Pain (P&M) | 'My back hurts most of the time so I don't tend to do much exercise' (P52) | 7 |
| Other commitments (Prac.) | I have not exercised 'due to work commitments' (P8) | 4 |
| Too tired to exercise (P&M) | 'I get too tired' (P3) | 3 |
| Lack of time (Prac.) | 'Sometimes I had no time' (P15) | 2 |
| Forget to exercise (P&M) | 'sometimes I forget' (P120) | 2 |
| Lack of motivation (Exer.) | 'It's hard to be motivated' (P30) | 2 |
| Exercise is boring (Exer.) | 'The exercises are boring and tedious' (P10) | 2 |
| No space to exercise (Prac.) | 'I live in quite a small flat, with a large family, so it's a bit cramped' (P138) | 2 |

Table 12 shows that the most frequently cited explanation for better exercise adherence behaviour was exercising to reduce pain (4 participants). This was followed by reducing disability (2 participants) and back health as a priority, exercising for happiness/enjoyment and exercising due to regular physiotherapist feedback (1 participant cited each explanation). The most frequently cited explanation for non-adherence to prescribed exercise was pain (7 participants) and other commitments (4 participants). This was followed by tiredness (3 participants) and lack of time, forgetting, lack of motivation, boredom and lack of space to exercise (2 participants cited each explanation).

Certain explanations cited by participants when answering the open-ended question were not included in the 10 'reasons' items. For example, feedback was not included in the 10 'reasons' items as a facilitator of exercise behaviour. Furthermore, the entire theme 'barriers directly related to exercise' (Exer.) was not accounted for in the 10 'reasons' items. One reason for this may be because participants of the focus group may not have wanted to state negative opinions regarding exercise with a physiotherapist and researchers present. Non-adherence due to other commitments was one explanation of adherence behaviour that showed the strongest relationship with adherence behaviour in Table 11 and was cited by the second greatest number of participants answering the open-ended question. Pain was the barrier to adherence that was cited most in this CLBP sample. However, Table 11 shows that pain and adherence behaviour as assessed by the EARS were only weakly associated with each other. This suggests that the EARS requires further assessment of validity in order to surmise more conclusively whether or not it accurately measures adherence behaviour. The qualitative data may be used alongside date from the 10 'reasons' items with the aim of forming a valid scale assessing reasons for adherence behaviour that could be used alongside the EARS. This is further discussed later in the chapter (Section 4.4.3.).

## 4.4. Discussion

This study reported the development and initial psychometric evaluation of the Exercise Adherence Rating Scale (EARS); a 6-item measure assessing adherence to prescribed home exercise in CLBP (Appendix 4b). To the author's knowledge, this is the first standardised, validated measure that assesses self-

reported adherence to prescribed home exercise. Examination of the scale structure of the 6-item scale revealed a one factor solution explaining a total of 66% of the variance in adherence to exercise. Internal consistency and IRT methods indicated that the reliability of this measure was acceptable, and test re-test reliability was high.

A remaining 10 items assessing reasons for adherence and non-adherence were not included in the final 6-item EARS questionnaire. Theory, research and patient/clinician feedback from the present research linked these items with adherence behaviour. Consequently, although the 10 items were not included in the main analysis, they provided additional evidence of convergent validity for the 6-item EARS (Table 11). Furthermore, the 10 items provide additional information via single-item questions that may assess reasons why an individual may or may not adhere to prescribed home exercise. Strong associations were found between 'other commitments' (item 1), 'time' (item 2) and adherence. These were closely followed by a medium association between being unsure how to do prescribed exercises (item 10) and adherence. These three items showed the strongest associations with adherence and therefore may be particularly useful when assessing non-adherence to prescribed home exercise in both research and clinical settings.

### 4.4.1. Research and clinical implications

The World Health Organisation recommended that healthcare providers (HCPs) advise patients with chronic conditions to exercise where it is known to benefit their condition (World Health Organisation, 2003). However, adherence to prescribed exercise in chronic conditions is poor (Beinart et al., 2013; Crandall, Howlett, & Keysor, 2013; Austin et al., 2012). To aid our understanding of why people do not adhere to prescribed exercise, systematic reviews have identified barriers and predictors of adherence to prescribed exercise in patients with chronic musculoskeletal pain (Beinart et al., 2013; Jordan et al., 2010; Jack et al., 2010). However, these reviews found it difficult to draw firm conclusions due to the absence of a valid and reliable measure to assess adherence. Attendance at appointments provided the only standardised assessment of adherence (Jack et al., 2010), however appointment attendance does not provide information about patient's adherence behaviour outside the

consultation (Kolt, Brewer, Pizzari, Schoo, & Garrett, 2007). This is a fundamentally different question to whether or not a patient attends their appointment and is methodologically more difficult to answer (Jack et al., 2010).

In addition to the aforementioned research, a recent systematic review investigated measures used to assess adherence to prescribed home exercise and their psychometric properties (Bollen et al., 2014). All clinical populations and health conditions were included in the review. Fifty-eight studies reported 29 questionnaires, 29 logs, two visual analogue scales and one mechanical counter used to assess exercise adherence. Bollen and colleagues (2014) assessed measures using quality criteria for measurement properties of health status questionnaires (Terwee et al., 2007). Out of 61 measures, only two scored positively for some psychometric properties described by Terwee and colleagues' (2007) nine quality criteria. The two measures were the Adherence to Exercise Scale for Older Patients (Hardage et al., 2007) and the Heart Failure Compliance Questionnaire (Evangelista, Berg, & Dracup, 2001), both of which scored positively for content validity. The lack of robust measures found by Bollen and colleagues (2014) further demonstrates the necessity for a measure that has been robustly psychometrically established. The evidence presented in this thesis indicates that the EARS is a reliable scale with sufficient validity to use as an appropriate tool for indicating the degree of adherence to prescribed home exercise. In relation to the Terwee and colleagues (2007) criteria, the author considers the EARS to meet six out of a total nine criteria. Criteria are not met with regards to criterion validity, responsiveness and agreement, as these aspects of psychometric evaluation require further research with additional measures and a repeated measures design.

Medication adherence has been more rigorously assessed and adherence and non-adherence are typically defined by a cut-off score. The cut-off score may vary depending on condition and type of medication (Ho et al., 2009), for example, pharmacological evidence has found that reduction in blood pressure requires medication adherence of >80 percent (Bryson, Au, Young, McDonell, & Fihn, 2007). However, a cut-off score may not be useful when assessing exercise adherence behaviour, as it is not clear what level of exercise is necessary for treatment to be effective. A cut-off score also assumes that a person is either adherent or non-adherent, and does not account for variation in

adherence behaviours. Assessment of different levels of exercise adherence and non-adherence is important from both a clinical and research perspective, as adherence behaviour may vary at either end of the continuum. For example, a person's behaviour may range from completely non-adherent to partially non-adherent, and where a cut-off score may remain the same (i.e. non-adherent), a score on the EARS continuum will account for higher and lower non-adherence, plus other aspects of adherence such as partial adherence, over-adherence and erratic adherence (Partridge, Avorn, Wang, & Winer, 2002). Understanding different levels of adherence may provide information that aids patient treatment as an HCP can amend ongoing treatment based on this information. From a research perspective, this information will provide a broader and more realistic understanding of adherence behaviours, thus aiding the development of interventions that may increase adherence to prescribed exercise.

### 4.4.2. Strengths and limitations

With the role of exercise now widely recognised as necessary for both primary prevention, secondary prevention and treatment of chronic illness (Kruk, 2007) it is of vital importance that adherence to prescribed exercise can be adequately assessed. A strength of the EARS is that it is the first validated measure that can reliably assess adherence to prescribed home exercise. However, the EARS experiences many of the same issues as any self-report measure, such as memory lapses, social desirability and recall bias. Nevertheless, it does represent a standardised method of assessing self-reported adherence, which is an important step forward.

One limitation of this research is that the sample used to validate the EARS was recruited mainly from one physiotherapy clinic at Guy's Hospital. The psychometric standing of the EARS may have benefited from a more varied sample recruited from a number of different clinics. This would have increased heterogeneity and provided a wider range of scores. A further limitation of the EARS relates to ambiguity with regards to item 6 'I do some, but not all, of my exercises'. It could be argued that it is unclear how the item relates to adherence behaviour. For example, using the 0 to 4 scoring system (completely agree '0' to completely disagree '4'), a person that completely disagrees with this item may mean that they are doing either all or none of their prescribed

exercises. This answer portrays both adherent and non-adherent behaviour, depending on what meaning is inferred from the item and its associated scoring. However, the ambiguity described here does not necessarily mean that the item is not a valid or reliable indicator of adherence and that it must be removed from the scale.

Item 6 is the last of the adherence items on the EARS. Therefore, people should be primed to infer meaning that higher scores mean better adherence. Furthermore, the item's mean correlation with the other 5 adherence items is .48 and its factor loading .56. This is the second lowest score for both mean correlations and factor loadings (ahead of item 4 'I fit exercise into my regular routine', which is less of a direct indicator of adherence). Although the aforementioned scores support the ambiguity argument, they are still relatively high. In addition to this, if the item is deleted, Cronbach's alpha reduces by .02. While this does not suggest that item 6 adds considerably to the reliability of the scale, the slightly lower validity introduced by the ambiguity of the item does not detract from the reliability of the scale. In addition to this, it may be argued that Item 6 could potentially improve the validity of the EARS since it is the only item to probe as to whether when people do their exercises they do them all, whereas most other items refer to the frequency with which exercises are done. For these reasons, rather than removing item 6 from the scale, further research may focus on amending the ambiguous item (e.g. to 'I do most or all of my exercises') and further validating it in future iterations.

The EARS would benefit from additional evaluation of construct validity, for example, the testing of discriminant and convergent validity. Discriminant validity refers to the notion that two constructs that are theoretically unrelated, are in fact unrelated. Relationships between exercise behaviour and exercise self-efficacy have been found repeatedly (e.g. Graham & Bray, 2015; Azizan, Justine & Kuan, 2013; McAuley et al., 2011; Bandura, 2004). Exercise adherence and exercise self-efficacy are theoretically different concepts. Therefore, it is important that the EARS is shown to measure adherence behaviour and not simply exercise self-efficacy. The Exercise Self-Efficacy Scale (EXSE) (McAuley, 1993) has been psychometrically evaluated and found to be a reliable (Cronbach's $\alpha = 0.92$) and valid questionnaire (construct and

criterion validity; correlations and Lambda X estimates = 0.61 to 0.87) (Resnick and Jenkins, 2000). Thus, the EXSE may be a suitable tool to examine discriminant validity of the EARS.

Convergent validity refers to whether two measures of the same construct that are assumed to be theoretically related, are in fact related. There may be difficulties selecting a measure suitable for investigating convergent validity due to the lack of psychometrically evaluated measures assessing exercise adherence behaviour (see Chapter 1, Section 1.2.3.). However, Bollen and colleagues' (2014) systematic review found two measures with some psychometric properties (content validity) that assessed exercise adherence behaviour; the Adherence to Exercise Scale for Older Patients (AESOP) (Hardage et al., 2007) and the Heart Failure Compliance Questionnaire (HFCQ) (Evangelista et al., 2001).

The HFCQ may not be a suitable measure to investigate convergent validity of the EARS for two reasons. Firstly, the HFCQ produces a total adherence score based on four sub-scales assessing adherence to medication, appointments, diet and exercise. Evidence that level of adherence varies across different types of adherence behaviour (e.g. Broadbent et al., 2011; Evangelista et al., 2001) suggests that it would be incorrect to assume that total HFCQ score would correlate sufficiently with the EARS to confirm convergent validity between the questionnaires. It may be argued that the exercise sub-scale of the HFCQ could be used, however, a further reason not to use the HFCQ is that heart failure and CLBP are two dissimilar chronic conditions that are likely to affect people, and their illness behaviours, differently. It is likely that barriers to prescribed exercise (e.g. chest pain versus back pain), as well as types of exercise prescribed, would differ between the two conditions. The AESOP may be a more suitable measure to investigate convergent validity of the EARS. The AESOP was validated in older patients (>65 years) where CLBP is likely to have played a role in exercise recommendations due to conditions associated with aging (e.g. osteoarthritis).

Testing convergent and discriminant validity would require a new sample of patients with CLBP to complete the EXSE, the AESOP and the EARS. Correlational analysis could then compare scores from the EXSE and the

AESOP to the EARS. It would be posited that low correlations (r≤.1) between the EXSE and the EARS would provide evidence of discriminant validity. Correspondingly, moderate to high correlations (r>.3) between the AESOP and the EARS would provide evidence of convergent validity. There are no fixed rules regarding how low or high a correlation needs to be to provide evidence of discriminant or convergent validity. However, these analyses would provide further evidence that the EARS is (or is not) measuring adherence behaviour, thus, producing a more rigorously evaluated tool.

Structural equation modelling (SEM) is a confirmatory technique that could also be used to extend findings of the present research regarding construct validity of the EARS. SEM may be used in an attempt to replicate the one-factor model found using EFA in the current study. A new sample of patients with CLBP would be required to complete the EARS. SEM analysis may then be used to identify whether the latent variable (i.e. adherence behaviour) found by the original EFA can be replicated in the new sample. In order to test goodness-of-fit of the SEM, the SEM may be fitted to both the original and the new dataset. Subsequent to this, analysis may examine measurement invariance of the model across both datasets simultaneously with the expectation that the model would be significant in both samples (p>.05). A significant value would indicate that the same construct is being measured by the EARS in both datasets.

SEM also allows for testing of relationships between constructs and the directionality of any significant relationships to provide evidence of discriminant and convergent validity (Schreiber, Nora, Stage, Barlow &King, 2006). SEM could be used to analyse multitrait-multimethod (MTMM) data in order to investigate convergent and discriminant validity of the EARS. SEM would allow for scores on the EXSE, the AESOP, the EARS and other measures of adherence behaviour (e.g. an electronic device and a diary) from a new CLBP sample to be compared on an MTMM correlation matrix. Different blocks of the MTMM matrix would provide information regarding strength of relationships between each measure, for example, the monotrait-heteromethod block would show correlations between the same construct as assessed by different methods. It would be posited that these correlations should be large (r>.5) in order to provide evidence of convergent validity.

### 4.4.3. Future research

Future research may include investigation of sensitivity to change, plus additional reliability and validity testing. Sensitivity to change is essential if the EARS is to be used to evaluate the effectiveness of interventions attempting to improve adherence behaviour. Criterion validity of the EARS alongside measures of pain and disability demonstrated no significant relationships between the two clinical measures and adherence behaviour. Therefore, criterion validity may be further investigated alongside additional clinical measures plus objective activity devices to support or refute these negative findings regarding criterion validity.

Validation using objective activity devices may best be done by investigation of specific types of prescribed exercise that can be reliably assessed by the objective activity monitor in question. A randomised controlled trial (RCT) where exercise recommendations are standardised may provide a controlled setting within which to further validate the EARS alongside objective activity devices. Furthermore, it would be advantageous to collect additional data from multiple samples exposed to different types of exercise programmes in order to examine the psychometric standing of the EARS across different types of exercise prescriptions.

In addition to further psychometric evaluation for the EARS, reasons for adherence behaviour should be examined further. Qualitative data from the open-ended question may be used alongside information from the 10 ‘reasons’ items to explore explanations of adherence behaviour in CLBP. The 10 ‘reasons’ items were not found suitable for EFA. However, this may be because reasons are formative indicators, rather than causal indicators, of a latent construct (Edwards & Bagozzi, 2000). This data may be explored using a formative construct approach with the aim of forming a valid scale assessing reasons for adherence behaviour that could be used alongside the EARS. A scale assessing reasons for adherence and non-adherence could provide useful data regarding specific areas of adherence behaviour where intervention may be required to improve clinical outcome in CLBP.

### 4.5. Conclusion

Prevalence data shows that between 50 percent (Friedrich et al., 1998) and 70 percent (Harkapaa et al., 1991; Reilly et al., 1989) of people with CLBP are non-adherent to prescribed home exercise. There is currently no valid and reliable method of assessing exercise adherence behaviour in chronic musculoskeletal conditions. The EARS provides a simple, standardised, reliable assessment of adherence to prescribed home exercise. This may facilitate the development and evaluation of interventions that encourage long-term self-management for both the prevention and treatment of chronic conditions.

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**Chapter summary**

This chapter described the development and initial psychometric evaluation of the 6-item EARS. To the authors' knowledge, the EARS is the first validated measure that assesses self-reported adherence to prescribed home exercise in CLBP. EFA revealed a one factor solution explaining a total of 66 percent of the variance in adherence to exercise. Internal consistency and item response methods indicated that the reliability of the EARS was acceptable, and test re-test reliability was high. Replication is needed, but initial evidence suggests that the EARS is a promising measure of adherence behaviour for use with a CLBP sample.

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# 5. Study 3: A Protocol

## 5.1. Overview

This chapter discusses a protocol for Study 3 based on Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) guidelines (Chan et al., 2013). SPIRIT guidelines were developed to improve the quality of clinical trial protocols. Therefore, features of the guidelines pertaining directly to clinical trials (e.g. randomisation and blinding) were not included in the current protocol. SPIRIT guidelines state that methods of analyses may be described away from the protocol. Therefore, for purposes of clarity, statistical methods are described in subsequent chapters prior to the results of baseline and follow-up analyses (Chapters 6 and 7 respectively).

This chapter begins with an introductory section providing information regarding background, rationales, research objectives and design for Study 3 (5.2.). The next section focuses on methods relating to the study setting, participant eligibility criteria and treatment, and sample size (5.3.). This is followed by discussion of the methods relating to procedures followed when conducting the research (5.4.). Subsequent to this, measures selected for the main study are described in detail (5.5.). Measures assessed psychosocial factors (5.5.1), clinical factors (5.5.2.) and executive functions factors (5.5.3.). Finally, adherence to prescribed home exercise is discussed as the primary outcome of the main study (5.5.4.).

## 5.2. Introduction

This section describes the background and rationales for Study 3 (5.2.1.). This is followed by reiteration of Research Objectives 3 to 5 and the hypothesis relating to the current study (5.2.2.). Study design is then described (5.2.3.).

### 5.2.1. Background and rationales for Study 3

CLBP is a major cause of disability in Western populations and an increasing problem of epidemic proportions (Descarreaux et al., 2002). Exercise programmes have been found to be moderately effective at reducing pain and improving function in CLBP (Hayden et al., 2005; Liddle et al., 2004; van Middelkoop et al., 2011). However, between 50 percent (Friedrich et al., 1998) and 70 percent (Harkapaa et al., 1991; Reilly et al., 1989) of individuals with

CLBP do not adhere to prescribed home exercises. Few studies have investigated factors that influence adherence to prescribed home exercise in individual chronic pain conditions such as CLBP (Jordan et al., 2010). Consequently, the present research investigates factors that predict exercise adherence behaviour in a CLBP sample.

Traditional health behaviour models (e.g. the theory of planned behaviour, (Ajzen, 1991) have been used as a theoretical basis for understanding and predicting engagement in exercise behaviour. However, traditional models of health behaviour only explain a small proportion of actual behaviour (28%) (Sheeran, 2002). Chapter 1 discussed the limited ability of traditional health behaviour models at predicting exercise behaviour. The present research explores this further by investigating factors not considered by traditional models of behaviour change. In order to do this, the concept of self-regulation was introduced in Chapter 1 as an explanation why individuals with CLBP may be non-adherent to prescribed home exercise. Ability to self-regulate appears to rely on executive functions (Nes et al., 2009). Furthermore, executive functions deficits have been found in individuals with CLBP (Wand et al., 2011). Therefore, the role of executive functions are believed to be particularly relevant in the present research investigating exercise adherence behaviour in CLBP.

Temporal self-regulation theory (TST) (Hall & Fong, 2007) is a useful framework to explain how deficits in executive function lead to difficulties initiating and maintaining exercise behaviour (Hall & Fong, 2010; Hall & Fong, 2007) (see Chapter 1 for more detailed information). According to Hall and Fong (2007), there are two executive functions that are relevant to the successful uptake of health behaviours. These two executive functions are: a) behavioural inhibition (where stronger inhibitory capacity is required for better ability to implement plans) and b) working memory (for the storage and capacity of information, e.g. exercise instructions). Furthermore, the TST posits that individuals with better executive functions are better able to use self-regulation to initiate exercise behaviour. Subsequent exercise behaviour leads to strengthening of executive function and related self-regulatory processes, thus sustaining the feedback loop and leading to maintenance of exercise behaviour in the long-term. Together with evidence of executive functions deficits found in individuals with

CLBP (Wand et al., 2011), the TST model provides a plausible explanation of exercise non-adherence in a CLBP sample.

The present study aims to extend current findings regarding exercise adherence behaviour in CLBP by investigating relationships between executive function, clinical and psychosocial factors and adherence to prescribed home exercise.

### 5.2.2. Research Objectives and Hypothesis for Study 3

The first objective of the current thesis was a systematic review assessing factors influencing adherence to prescribed home exercise in CLBP (Chapter 2). The second objective resulted in the development and initial psychometric evaluation of a brief measure to assess adherence to prescribed home exercise (Chapter 3). Study 3 is based on research objectives 3, 4 and 5 and a hypothesis.

Research Objective 3 aims to assess and examine relationships between psychosocial, clinical and executive function factors in individuals with CLBP. CLBP is characterised by debilitating levels of self-reported pain and disability (Savigny et al., 2009). Psychosocial factors (e.g. anxiety, depression, beliefs, fear-avoidance beliefs and pain catastrophizing) have been associated with the maintenance of pain and disability in CLBP (e.g. Tangestani, 2012; Thomas et al., 2010). Furthermore, individuals with CLBP have neurological changes and executive function deficits that may lead to difficulties following treatment advice, such as, advice to exercise (Hagger et al., 2010; Hall et al., 2008). Therefore, the focus of the third research objective is to assess and examine relationships between psychosocial, clinical and executive function factors prior to physiotherapy treatment in a sample of adults with CLBP. This cross-sectional analysis allows for the comparison of the CLBP sample to normative data and other CLBP samples. Additionally, correlational analysis provides insights into relationships between psychosocial, clinical and executive function factors in CLBP.

Research Objective 4 aims to evaluate the possible roles of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in CLBP. Psychosocial factors (e.g. distress) and clinical factors (i.e. pain and disability) have been associated with adherence to prescribed home exercise in

CLBP (Beinart et al., 2013). Executive functions have been found to predict exercise behaviour in a healthy sample (Hall et al., 2008). The influence of executive functions is posited to be particularly relevant to exercise behaviour in a CLBP sample because executive function deficits have been found in individuals with CLBP (Wand et al., 2011). Therefore, the fourth research objective investigates the predictive value of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in a CLBP sample. This is tested by construction of multiple regression models with predictors based on theoretical and statistical rationales.

Research Objective 5 aims to determine whether adherence to prescribed home exercise is related to clinical outcome. Relationships between clinical outcome and exercise adherence behaviour have rarely been assessed. The few studies that have investigation these relationships found no relationships between changes in clinical outcome and adherence (Mailloux et al., 2006) and inverse relationships between disability (Harkapaa et al., 1991), pain (Donzelli et al., 2006) and subsequent adherence behaviour. Exercise is a main treatment prescribed to treat CLBP (NICE, 2009). Lack of research in this area indicates that further investigations are necessary to improve understanding of relationships between clinical factors that characterise CLBP as a chronic condition (i.e. pain and disability) and exercise adherence behaviour. Thus, the fifth research objective assesses relationships between adherence to prescribed home exercise and self-reported disability and pain. Correlational analysis investigates relationships between baseline clinical factors and changes in clinical factors over time, and subsequent adherence behaviour.

Study 3 hypothesises that executive functions will predict additional variance in adherence behaviour over and above that which is explained by psychosocial and clinical variables. Much of the research investigating relationships between executive functions and health exercise behaviours has focused on the positive effects of exercise on executive function processes in healthy samples (Buckley et al., 2014). In contrast, less research has investigated the influence of executive functions on exercise behaviour (Hall et al., 2008; Hall & Fong, 2007). However, preliminary evidence has found that executive functions are predictive of exercise behaviour in healthy samples (McAuley et al., 2011; Riggs et al., 2010; Hall et al., 2008). Therefore, in Study 3, executive functions are posited to

predict additional variance in adherence behaviour over and above that which is explained by psychosocial and clinical factors.

### 5.2.3. Study design

This was a prospective, observational study with follow-up at 3 months. Ethical approval was given by Dulwich Research Ethics Committee (REC reference: 10/H0808/09). There were two stages to the study:

1. Baseline assessment was done in person, prior to start of physiotherapy treatment. Psychosocial, clinical and executive function measures were completed, together with a demographics questionnaire and informed consent.

2. Follow-up at 3 months was done over the telephone and consisted of reassessment of clinical measures and the Exercise Adherence Rating Scale (EARS) questionnaire to assess adherence behaviour as the main outcome. Physiotherapists were asked to complete the Sports Injury Rehabilitation Adherence Scale (SIRAS, Appendix 7) (Kolt et al., 2007) as a measure of adherence behaviour at this time.

## 5.3. Methods: Study setting and participants

This section describes the study setting and initial procedures followed to recruit potential participants (5.3.1.). Eligibility criteria are discussed next (5.3.2.). This is followed by description of three types of physiotherapy treatment that participants included in Study 3 may attend (5.3.3.). This section also discusses prescribed home exercise for each of the three types of treatment. Participant timeline including enrolment into the study and time points for baseline and follow-up assessments is described next, as per SPIRIT guidelines (5.3.4.). Lastly, a power calculation explains minimal sample size required for subsequent statistical analyses (5.3.5.).

### 5.3.1. Study setting and procedure

Participants were recruited from physiotherapy departments at Guy's and St. Thomas' Hospitals (GSTT) and King's College Hospital (KCH) using opportunistic sampling methods. To discover which patients were attending the

physiotherapy departments for problems of CLBP, lists of patients with physiotherapy triage appointments were accessed by the researcher each week using Patient Management Software (PMS). Once this list was obtained, referral letters were accessed to gain information about reasons for referral for physiotherapy treatment. Electronic Patient Records (EPR) software was used to access referral letters. Those who were referred for musculoskeletal (MSK) problems due to CLBP (or LBP with no stated duration) were posted an invitation letter (Appendix 5) and information sheet (Appendix 1) about the study. The information sheet explained: a) the purpose of the study, b) why they had been chosen, c) the procedures and tests involved, d) what would happen to collected data, e) the benefits and possible disadvantages of taking part in the study, f) who could be contacted if there was a problem, and g) confidentially regarding data.

Triage procedures were different at GSTT and KCH hospitals and this affected first contact with potential participants. After attending their triage session, patients at GSTT hospitals were approached at the relevant physiotherapy department. They were asked if they had received information about the study and if they were interested in participating. KCH had a telephone triage process, therefore potential participants were contacted by telephone within 24 hours of having their triage appointment. Participants who wished to participate in the study were asked screening questions to check that they satisfied inclusion criteria for entry into the study (Appendix 6).

### 5.3.2. Eligibility criteria

A premise of the current research was that pain negatively influences executive functions in people with CLBP (e.g. Wand et al., 2011) (see Chapter 1, Section 1.4.1.). Based on this premise, age was restricted in an attempt to control for the effects of increasing age on executive functions (e.g. Zelazo, Craik & Booth, 2004). A further reason for an age restriction was to control for the potential confounding effects of age-related co-morbid illness in the CLBP sample. It was believed that without this age restriction, it might be difficult to distinguish whether the presence of executive function deficits in older adults with CLBP may be due to older age, an age-related co-morbid illness or their CLBP condition.

It was difficult to decide at what age people should be excluded from the study. Lack of longitudinal research has led to difficulties clarifying what constitutes 'older' age with regard to decline in executive functions (Salthouse, 2012). Research investigating executive functions in 'older' adults has included adults of varying ages with no explanation regarding age restriction (e.g. ≥ 52 years; Kobayashi, Wardle, Wolf & von Wagner, 2015; ≥ 55 years; Kobayashi, Smith, et al., 2015). However, a large longitudinal study investigating executive functions in adults aged 50 to 85 years found a significant acceleration in the decline of executive functions in adults over the age of 65 years (The Swedish Adoption/Twin Study of Aging; Finkel & Pederson, 2010). In the absence of clear guidance regarding a suitable age range necessary to reduce the impact of age-related cognitive decline, it was considered acceptable to restrict the age of participants from 18 to 65 years of age.

It was believed that this age restriction might reduce the likelihood of co-morbid illnesses influencing ability to follow exercise advice. Risk for several chronic illnesses rises with increasing age (Kobayashi, Smith, et al., 2015). Furthermore, a person with co-morbid chronic illnesses may require medication and exercise prescriptions additional to exercises prescribed for their CLBP condition. In addition to this, some co-morbid illnesses may have physical and emotional side-effects. Thus, co-morbid chronic illnesses are associated with multiple factors that could influence adherence behaviour and be difficult to control for in the present study. It may be argued that participants of any age with a co-morbid chronic illness could be excluded from participating in the research. However, it would have been problematic to monitor this exclusion criterion in older adults who are more likely than younger adults to have symptoms of co-morbid illness, yet be undiagnosed at the time of recruitment. It was therefore considered necessary to reduce confounding problems related to co-morbidity by excluding participants over 65 years of age.

Inclusion criteria was as follows:

- CLBP of 12 weeks of more; with or without leg symptoms.

- 18 to 65 years of age. Age range was restricted to control for potential confounding factors that would otherwise bias the results of the study (i.e. age-related cognitive decline and age-related co-morbid illness).
- Participation as a treatment patient for non-specific CLBP in physiotherapy departments at GSTT or KCH.
- Prescription for home exercises.
- Fluent in written and spoken English.

Exclusion criteria was as follows:

- Unable or unwilling to give consent.
- Having LBP of 12 weeks of more due to pregnancy.
- Having LBP that is attributable to a recognisable, known specific pathology (e.g. infection, tumour, osteoporosis, fracture, structural deformity, inflammatory disorder (e.g. ankylosing spondylitis), radicular syndrome or cauda equina syndrome).
- Having neurological, psychiatric or intellectual disturbances, such as, presence of head injury, stroke, dementia, major depression, psychiatric illness, epilepsy, drug abuse or alcohol abuse.
- Colour blindness or very poor eyesight were part of the exclusion criteria because many of the questionnaires and tests involve reading and the Stroop test relied on ability to distinguish colours.

### 5.3.3. Physiotherapy treatment for patients with CLBP

Patients with CLBP were assessed for their suitability for various forms of therapy in their 30 minute triage appointment. Some patients may be managed on a 1:1 basis (5.3.3.1.), whilst others are referred into one of two back classes (5.3.3.2.). A back rehabilitation class, combining education and exercise, was recommended for those patients who presented with any form of centrally sensitised pain and were globally deconditioned. Patients who presented with a higher level of function were referred to a dynamic control back class. Any of these individuals may also have received 1:1 physiotherapy prior to a suitable back class. Prescribed home exercises for 1:1 physiotherapy (5.3.3.1.1.) and back classes (5.3.3.2.1.) are described in the following section.

#### 5.3.3.1. Individual 1:1 physiotherapy sessions

Individual 1:1 physiotherapy sessions incorporated movement and exercise and/or manual therapy techniques. In some cases acupuncture may have been used to help reduce inflammation and pain. Movement and exercise was used to improve mobility and strengthen targeted areas of the body (NHS, 2014). Depending on the specifics of the individual case, manual therapy may have been utilised if a myofascial deficit was apparent and had the potential to be improved with methods such as massage, joint mobilisation, mobilisation with movements (MWMs) and hold and relax techniques.

##### 5.3.3.1.1. Prescribed home exercise for 1:1 physiotherapy sessions

All patients were prescribed home exercises to repeat regularly each week. Patients were asked to perform these exercises daily if possible, or less if more manageable. Patients were advised to practice specific exercises that they performed with the assistance of a physiotherapist in their treatment session. Patients were advised that no particular form of exercise has been shown to be of more benefit than another, therefore they should choose any exercise that they enjoy and slowly increase the frequency and intensity of that exercise. They were also told that staying active and doing regular exercise would help to prevent their condition becoming worse. Pictures and descriptions were provided of specific exercises to be performed on a regular basis. Amongst more specific exercises for individual conditions, four key exercises were generally recommended. These were i) standing in extension, ii) side bends, iii) knee rolls and iv) sit to stand.

#### 5.3.3.2. Back classes for CLBP

There were two types of group back class recommended for patients with CLBP at all hospitals, the back rehabilitation class and the dynamic control class. In the case of both types of back class, a band 6 or 7 physiotherapist supervised each class and a band 5 physiotherapist would rotate every four months.

#### 5.3.3.2.1. Back rehabilitation class

Both classes included up to 8 patients at any one time. The back rehabilitation classes was aimed at adults with long-term CLBP who had been inactive in daily life for some time. Therefore patients in this class tended to be older than those in the dynamic control class. The classes consisted of circuit-based exercises with the aim of improving the movement and coordination of the trunk, lower back and pelvic regions. This class at GSTT consisted of six sessions, including 45 minutes of exercise plus 45 minutes of education (including discussion of anatomy and physiology, pacing and dealing with flare ups). Patients attended one class a week for six weeks. The back rehabilitation class at KCH consisted of six sessions including 30 minutes of exercise plus 30 minutes of education. Patients attended two classes a week for 3 weeks.

Patients in the back rehabilitation classes at GSTT (but not at KCH) were provided with an educational booklet called 'The Physiotherapy Back Rehabilitation Programme'[2]. This book consisted of information regarding the six educational sessions that patients would attend at their back classes. These sessions were i) spinal anatomy and posture, ii) chronic pain, iii) managing exercise, pacing and goal-setting, iv) relaxation, v) challenging thoughts about low back pain and vi) managing and coping with flare-ups. All of the exercises taught in class were included in the booklet. Pictures and descriptions of the following types of exercise were provided. These were i) warm-up exercises, ii) stretches, iii) circuit exercises and iv) cool down exercises. Patients at KCH were provided with leaflets consisting of pictures and descriptions of exercises performed in class, plus information regarding remaining active and exercising regularly.

#### 5.3.3.2.2. Dynamic control class

The dynamic control class was aimed at adults with CLBP of any length, but who had previously been quite active and were considering returning to high level exercise or sporting activities. This was a 60 minute Pilates-based

[2] Since June 2014 an updated version of the booklet has been available online (https://www.guysandstthomas.nhs.uk/resources/patient-information/therapies/physiotherapy/advanced-back-rehabilitation-programme.pdf).*

exercise class. At GSTT, patients attended one class a week for six weeks. At KCH, patients attended two classes a week for 3 weeks. Patients in the dynamic control class at GSTT (but not at KCH) were provided with a booklet[3] including pictures and descriptions of Pilates exercises performed in class. This booklet also including information remaining active and exercising regularly, plus general benefits of regular exercise. Information regarding how to cope with flare-ups, pacing and general lifestyle advice relating to back pain (e.g. sleeping on a supportive mattress, postural advice at work and heavy lifting advice). Patients at KCH were provided with leaflets consisting of pictures and descriptions of exercises performed in class, plus information regarding remaining active and exercising regularly.

#### 5.3.3.2.3. Prescribed home exercise for back classes

Patients in both types of back class were advised to continue doing their taught exercises at home. They were also advised to continue doing any exercises recommended in 1:1 physiotherapy treatment sessions prior to attending a back class. It was suggested that they pick two of these exercises to concentrate on at home. Patients were asked to do continue performed the two exercises on a regular basis, or less if more manageable. Patients were also asked to remain active in general. Additionally, it was suggested that patients choose an enjoyable exercise and gradually increase frequency and intensity of this exercise until they were doing approximately 20 minutes three to five times a week. They were also advised to continue exercising, even if their condition improved, as regular exercise reduces the risk of pain returning. Patients attending the back rehabilitation classes at GSTT were provided with an activity diary that they were asked to complete each week. The diary stated each day of the week and included hourly slots ranging from 7am to 11pm.

### 5.3.4. Participant timeline

SPIRIT guidance highly recommends a table displaying participant timelines including enrolment into the study and time points for baseline and follow-up

[3] Since June 2013 an updated version of the booklet has been available online (http://www.guysandstthomas.nhs.uk/resources/patient-information/therapies/physiotherapy/dynamic-control-exercise-class-booklet.pdf).

assessments (Table 13). The SPIRIT template for participant timelines was modified for use in this study.

**Table 13*. Time schedule of enrolment and assessment for Study 3***

| | **STUDY PERIOD** (end Aug. 2013) | |
|---|---|---|
| | **Enrolment** | **Time 1** |
| **TIMEPOINT** | October 2011 | 3 months |
| **ENROLMENT:** | | |
| Eligibility screen | X | |
| Informed consent | X | |
| **ASSESSMENTS:** | | |
| Demographics | X | |
| Psychosocial, clinical and executive function baseline variables | X | |
| Main outcome: adherence (EARS) | | X |
| Reassessment of clinical variables | | X |

*Note*: EARS = Exercise Adherence Rating Scale

### 5.3.5. Sample size

A power analysis was calculated to determine the number of participants required to estimate the detectable correlation (r) for multiple regression analyses with statistical power of β =.80 and significance criterion of α =.05. G*Power 3 software was used to perform the power analysis (Faul, Erdfelder, Buchner, & Lang, 2009).

Cohen (1992) describes relationships between four statistical variables:

i) Sample size (n)
ii) Significance criterion (α)
iii) Population effect size (ES)
iv) Statistical power (β).

These four variables are related in that the value of any one of them can be determined from the other three variables. Significance criterion is commonly set at .01, .05 or .10 to indicate the percentage of chance of rejecting the null hypothesis when it is in fact correct (a Type 1 error). There are no statistically-based standards for significance criterion, therefore significance was set at α =.05 as is common practice in psychological research (Lavrakas, 2008). This criterion indicates a 5% chance of rejecting the null hypothesis when it is in fact correct (a Type 1 error). ES is based on the variance explained scale (r) and is related to the degree to which the null hypothesis is believed to be false. Cohen (1992) recommends that ES is defined as small (r = .02), medium (r = .15) or large (r = .35) the purposes of a sample size calculation. A medium ES was employed for power analysis as there was no available data on expected ES and .15 is the average ES of observed effects in many fields of research (Cohen (1992). Statistical power of 80% (β=.20; i.e. a 20% probability of making a Type 2 error) was proposed as a smaller value would increase the risk of a Type 2 error and a larger value would result in a sample size too large to recruit in the allocated time without more extensive resources.

Minimum required sample size was calculated to be n=127 (β=.20, ES=.15, α=.05). Attrition rates commonly range from 15 to 20 percent in psychological research (Enders, 2003). Furthermore, Tabachnick and Fidell (2001) suggest allowing for 20 percent attrition. Therefore, 20 percent of 127 was added to the

sample size to account for participant attrition. This resulted in a minimum acceptable sample size of n=152 for baseline data collection[4].

### 5.4. Methods: Data collection

Eligible participants who wished to participate in the study were asked if they were willing to arrive 1 hour before their first physiotherapy appointment to complete baseline measures. Baseline assessment was carried out by the researcher in a quiet room in the relevant physiotherapy department. Participants were given a battery of standardised and widely used, paper-and-pencil or spoken, measures. Psychosocial, clinical and executive function measures were completed, together with a demographics questionnaire and informed consent. At the end of baseline testing, participants were reminded that they would be contacted in 3 months to complete further measures. The first follow-up time of 3 months was selected based on physiotherapist feedback that patients with non-specific CLBP were likely to have been discharged with prescribed home exercise advice prior to the 3 month time point.

Physiotherapists were asked to complete a brief measure of adherence behaviour for patients that participated in the study (SIRAS, Appendix 7). A brief (approximately 5 minute) presentation was given at each physiotherapy department every 12 weeks throughout the recruitment process. This presentation described the study and gave physiotherapists the opportunity to ask questions. This also provided the opportunity to involve physiotherapists in choosing a practical and effective method of collecting physiotherapist adherence data. It was decided that email would be the best method to ask for physiotherapist's views on their patient's adherence to prescribed home exercise.

[4] After data collection had been completed, it was highlighted that the target sample size had incorrectly accounted for attrition. The target sample size accounting for 20% attrition should have been 159. Whereas, the stated number of 152 accounted for 16.5% attrition, which is within the range indicated as being expected by Enders (2003).

## 5.5. Measures

This section describes measures selected for the study investigating the roles of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in CLBP. A demographics questionnaire was completed initially (Appendix 8). This included information regarding gender, age, height, weight, ethnic group, education, employment, medication for back pain and duration of CLBP. Measures assessing psychosocial factors (5.5.1), clinical factors (5.5.2) and executive functions factors (5.5.3) were assessed subsequent to this. The primary outcome of the study was adherence to prescribed home exercise as assessed by the EARS (5.5.4). The full test battery can be found in Appendices 8 to 15 (plus the EARS in Appendix 4b).

The relevance of each measure is briefly described with regards to CLBP and adherence to prescribed home exercise. Detailed information regarding factors assessed by these measures and their relevance to CLBP and adherence behaviour has been provided in Chapter 1. Alternative measures that were considered for use in the study are discussed. Furthermore, psychometric data are provided where they are established and available. Each measure is briefly described and scoring information and normative data (where available) is provided. Data regarding internal consistency (Cronbach's alpha) is provided for each multi-item questionnaire to display the extent to which all items within a questionnaire are measuring the same concept with regards to the present CLBP sample. Acceptable values of Cronbach's alpha (α) range from upwards from α =.70 (Tabachnick & Fidell, 2001; Tavakol & Dennick, 2011).

### 5.5.1. Psychosocial Measures

Psychosocial measures included the assessment of general health status and social support using two single-item measures (5.6.1.1.). Multi-item questionnaires were used to assess anxiety, depression and overall distress (Hospital Anxiety and Depression Questionnaire; HADS) (5.6.1.2), illness perceptions (Brief Illness Perceptions Questionnaire; BIPQ) (5.6.1.3), fear-avoidance beliefs (Fear-avoidance Beliefs Questionnaire; FABQ) (5.6.1.4) and pain catastrophizing (Pain catastrophizing Scale; PCS) (5.6.1.5).

#### 5.5.1.1. **Single-item measures** (Appendix 9)

General health status (5.6.1.1.1) and social support (5.6.1.1.2) were assessed using single-item measures. It was acknowledged that in some cases single-item measures may be less psychometrically robust and would provide limited information compared to their longer counterparts. However, due to time considerations, it was necessary to assess these two variables using single-item measures.

##### 5.5.1.1.1. General health status

General health status was assessed using the first item from the 36-item Short-form Health Survey (SF-36) (Hays, Sherbourne, & Mazel, 1993). The question asked: “In general, would you say your health is: Excellent, very good, good, fair, or poor?” The SF-36 is a widely used measure of quality of life that has been used with a variety of chronic health problems (Bowling, 2005), including CLBP (Bronfort & Bouter, 1999). Research has reported that this single general health status item can predict mortality and health services utilisation (DeSalvo, Fan, McDonell, & Fihn, 2005). Furthermore, it has been significantly associated with change in functional status and recovery from ill health (Siegel, Bradley, & Kasl, 2003; Lebanon, 1999; Greiner, Snowdon, & Greiner, 1999; Idler & Kasl, 1995). A score of 1 to 5 was possible for this item, where a higher score indicated poorer health.

##### 5.5.1.1.2. Social support

Perceived social support has been shown to influence adaptation to chronic illness (Cohen, Mermelstein, Kamarck, & Hoberman, 1985; Valente, Ribeiro, & Jensen, 2009). Furthermore, poor social support has been associated with poor adherence behaviour in mixed MSK samples (Karnad & McLean, 2011; Jackson, Leclerc, Erskine, & Linden, 2005; Martin & Sinden, 2001). Social support is not often assessed in CLBP alone and this leads to difficulties determining particular domains of social support relevant to assess in a CLBP sample. Furthermore, time constraints led to investigation for a single-item measure of social support.

There are two types of social support that are commonly described in studies assessing chronic illness samples. These are network support (e.g. number of contacts and frequency of contact) and functional support (e.g. economic support and instrumental support) (Lett et al., 2009). Numerous questionnaires have been used to assess different domains of social support in chronic illness samples. These include the Perceived Social Support Scale (PSSS) (Zimet, Dahlem, Zimet, & Farley, 1988), the Social Networks Questionnaire (SNQ) (Glass, De Leon, Seeman, & Berkman, 1997) and the ENRICHD Social Support Instrument (ESSI) (Mitchell et al., 2003). However, several measures are required to assess a variety of domains of social support (Lett et al., 2009). Furthermore, single-item measures of social support that were found only assessed quantity of social support (i.e. number of people in one's social network) (Blake & McKay, 1986). Recent evidence suggests that quality, rather than quantity, of social support is the best predictor of health (Gottlieb & Bergen, 2010; Fiorillo & Sabatini, 2011). As social support was not a primary consideration in this study, it was decided to follow the advice of Bowling (2005) regarding the use of single-item measures. This was an attempt to find a balance between psychometric acceptability and practicality in terms of time (Bowling, 2005).

The ESSI is a reliable and valid measure of social support that has been found to apply equally well to people with different chronic illnesses (Gottlieb & Bergen, 2010). Therefore, the following question was selected from the ESSI to provide an assessment of social support in the present study: "Is there someone available to you to give you good advice about a problem?" Yes / No. It was acknowledged that this item may provide a general overview of the quality of a participant's social support network, but that caution must be taken when inferring from results using this item.

#### 5.5.1.2. **Hospital Anxiety and Depression Scale** (Zigmond & Snaith, 1983) (Appendix 10)

Anxiety and depression have been found to play a key role in the development and maintenance of CLBP (Nagarajan & Nair, 2010; Kendall, 1999; Pincus & McCracken, 2013). In addition to this, both lower and higher distress have been associated with adherence to prescribed home exercise (Harkapaa et al., 1991;

Friedrich et al., 1998 respectively). Therefore, it is recommended that mood be assessed when investigating executive functions in a chronic pain condition, as these three factors are associated with the same areas of the brain (i.e. the prefrontal cortex) (Siddiqui, Chatterjee, Kumar, Siddiqui, & Goyal, 2008).

Individual measures were initially considered for the assessment of anxiety and depression in the CLBP sample. This is because individual measures are considered to discriminate better between the separate dimensions of mood in clinical practice (Beuke, Fischer, & McDowall, 2003). The Spielberger State-Trait Anxiety Inventory (STAI-6; Marteau & Bekker, 1992) and the Beck Depression Inventory (BDI; Beck et al., 1961) were both considered. However, inclusion of somatic items in the BDI rendered it less reliable for use with a chronic illness sample where somatic symptoms (e.g. sleep disturbance and loss of appetite) may be due to characteristics of the condition rather than depressive state. The BDI includes one item assessing suicidal thoughts or wishes. It was believed that this may cause emotional distress in a situation where patients are not in a clinical setting where they may receive urgent treatment or intervention. The 9-item Patient Health Questionnaire (PHQ-9; Kroencke, Spitzer, & Williams, 2001) was not selected to assess depression due to the same reasons as the BDI.

Consequently, the Hospital Anxiety and Depression Scale (HADS) was selected to assess mood in the present study. The HADS was developed for use with patients with physical illness conditions (Keeley et al., 2008). Furthermore, the HADS has been found to effectively screen the separate dimensions of anxiety and depression in non-psychiatric settings (Bjelland, Dahl, Haug, & Neckelmann, 2002). Moreover, the HADS has been shown to be reliable, valid and responsive measure of anxiety and depression in MSK rehabilitation contexts (Pallant & Bailey, 2005) and chronic pain samples (Nicholl et al., 2009), including CLBP (Zenker et al., 2006). With regards to psychometric properties of the HADS, the anxiety, depression and total distress scales of the HADS have shown good reliability with Cronbach's α of 0.82, 0.77 and 0.86 respectively (Crawford, Henry, Crombie, & Taylor, 2001). Internal consistency for the HADS in the present study was acceptable: α = .772 (anxiety sub-scale), α = .778 (depression sub-scale) and α = .859.

The HADS is a brief, 14-item measure of depression and anxiety that asks participants to state their mood over the past week. Depression and anxiety are assessed by seven items each, and responses are scored on a scale from 0 (most of the time) – 3 (not at all). After reverse scoring the necessary items, a higher score indicates greater depression or anxiety. A total scale score may be calculated to indicate degree of overall psychological distress (Härter, Gross-Hardt, & Martin 2001; Crawford et al., 2001). There is no accepted cut-off score for anxiety and depression (Herrmann, 1997). Authors of the HADS recommended that scores of 8 – 10 identified mild cases, 11 – 15 identified moderate cases, and > 16 identified severe cases of anxiety and depression (Zigmond & Snaith, 1983). However, it has since been suggested that people scoring 8 - 10 are not categorised as having a mild case of anxiety and/or depression. This is due to a validation study finding that a considerable proportion of a healthy UK sample scored between 8 and 10 on the HADS (Crawford et al., 2001). They concluded that only moderate and severe cases of anxiety and depression (i.e. scores of ≥ 11) should be yielded by the HADS.

#### 5.5.1.3. **The Brief Illness Perception Questionnaire** (Broadbent et al., 2006) (Appendix 11)

Illness perceptions have been shown to predict high disability and inactivity in LBP, thus influencing the development and maintenance of CLBP (Foster et al., 2008; Foster et al., 2010). Illness perceptions have only recently been investigated in relation to exercise adherence in CLBP. An intervention targeting illness perceptions was found to increase exercise behaviour in a CLBP sample (Siemonsma et al., 2013). Furthermore, illness perceptions have predicted non-adherence to prescribed exercise in other chronic illness samples, including coronary heart disease (Platt, Green, Jayasinghe, & Morrissey, 2014) and type 2 diabetes (Broadbent, Donkin, & Stroh, 2011). The results of this research provide the basis for exploring illness perceptions and exercise adherence further in a CLBP sample.

The Brief-Illness Perceptions Questionnaire (Brief-IPQ) was selected to assess participants' cognitive representations of their CLBP condition. The English version of the Brief-IPQ has been used in 98 studies (Broadbent et al., 2015). However, only one of these studies included a CLBP sample (Dean, Hudson,

Hay-Smith, & Milosavljevic, 2011) and a further study assessed a mixed MSK sample (Brown, Dean, Hay-Smith, Taylor, & Baxter, 2010). More recently a Dutch sample with acute LBP (Hallegraeff, van der Schans, Krijnen, & de Greef, 2013) and two Norwegian samples with mixed acute and chronic LBP (Storheim, Brox, Løchting, Werner, & Grotle, 2012) have used the Brief-IPQ in their respective languages. Consequently, it was acknowledged that the English version of the Brief-IPQ has been used less than its longer counterparts with a CLBP sample (i.e. the Illness Perception Questionnaire; Weinman, Petrie, Moss-Morris, & Horne, 1996; and the Revised Illness Perception Questionnaire, IPQ-R; Moss-Morris et al., 2002). In addition, the Brief-IPQ has been shown to correlate well with subscales of the IPQ-R ($r$ = 0.32–0.63) (Broadbent et al., 2006; Raftery et al., 2011), which has been used more often than the Brief-IPQ with CLBP samples. Internal consistency for the Brief-IPQ in the present study was acceptable: α = .752. The Brief-IPQ was the most suitable choice of illness perception questionnaire due to its brevity. Therefore, the Brief-IPQ was selected to assess illness perceptions in the present CLBP sample.

The Brief-IPQ includes eight items scored on 0 – 10 scale, as well as a ninth qualitative item. Broadbent and colleagues (2006) suggest the adaption of the questionnaire to suit the illness being studied; therefore, the word 'illness' was changed to 'back pain' for the purposes of this study. Each of the eight items assessed one dimension of illness perceptions. These were: i) consequences; ii) timeline; iii) personal control; iv) treatment control; v) identity; vi) coherence; vii) emotional representation; and viii) concern about CLBP. Item 9 asked participants to state perceived causes for their CLBP. Each of the first eight items were given a score from 0 – 10 and the score for each illness perception was simply the score for that item. After reverse scoring certain items, an overall score representing the degree to which participant's CLBP was perceived as threatening of benign was computed. A higher score indicates a more threatening view of CLBP.

#### 5.5.1.4. **Fear-Avoidance Beliefs Questionnaire** (Waddell et al., 1993) (Appendix 12)

Fear-avoidance beliefs have been found to predict poor outcome in CLBP (Rainville et al., 2011; Nagarajan & Nair, 2010; Mannion et al., 2001; Pincus & McCracken, 2013; Meyer, Tschopp, Sprott, & Mannion, 2009; Grotle, Vøllestad,

Veierød, & Brox, 2004). Studies have also found that pain-related fear beliefs predict avoidance of physical activity in the daily life of individuals with CLBP (Goubert et al., 2005; Al-Obaidi et al., 2003). However, fear-avoidance beliefs have rarely been assessed in relation to non-adherence to prescribed exercise in CLBP (Mannion et al., 2009). Therefore, fear-avoidance beliefs are assessed in the present study to investigate whether they are predictive of adherence behaviour in the present CLBP sample.

The Fear Avoidance Beliefs Questionnaire (FABQ) was developed for use with CLBP samples. Consequently, it has been used with numerous CLBP samples (e.g. Rainville et al., 2011; Nagarajan & Nair, 2010; Thomas et al., 2010; Williamson, 2006; Keeley et al., 2008). The FABQ is a reliable measure of fear avoidance in CLBP, with a Cronbach's α of 0.88 and 0.77 for the work and physical activity sub-scales respectively (Waddell et al., 1993). Furthermore, the FABQ correlates with the Roland Morris Disability Questionnaire (FABQ work $r$ = 0.63, FABQ physical activity $r$ = 0.51; Kori, Miller, & Todd, 1990), in addition to other measures of fear-avoidance (e.g. the Tampa Scale of Kinesiophobia, FABQ work $r$ = 0.53, FABQ physical activity $r$ = 0.76; Kovacs et al., 2006). Internal consistency for the FABQ in the present study was acceptable: α = .825 (FABQ work), α = .645 (FABQ physical activity). A lower alpha level was expected for the FABQ physical activity scale due to the brief length of the test (4 items) compared to the longer (7 item) FABQ work scale. Together with the fact that the alpha level for the FABQ physical activity scale was nearing α =.70, the sub-scale to be deemed acceptable for use in subsequent analyses.

The FABQ is a 16-item questionnaire that assesses how much fear and avoidance are affecting a patient with CLBP. Participants answer five questions pertaining to fear-avoidance beliefs about physical activity and eleven questions pertaining to fear-avoidance beliefs about work. A score is summed for each sub-scale with a possible scores of 0-6 for each item on both scales. Scores on the physical activity scale can range from 0-24. Scores on the work scale can range from 0-42. On both sub-scales, a higher score indicates a higher tendency to avoid physical activity or work due to fear of pain.

#### 5.5.1.5. **Pain Catastrophizing Scale** (Sullivan, Bishop, & Pivik, 1995) (Appendix 13)

Pain catastrophizing has been shown to predict levels of self-reported disability in CLBP (Thomas et al., 2010; Moldovan, Onac, Vantu, Szentagotai, & Onac, 2009; Mannion et al., 2001). However, only one study has assessed pain catastrophizing in relation to non-adherence to exercise in CLBP (Mannion et al., 2009). Pain catastrophizing did not predict adherence behaviour in Mannion and colleagues' (2009) study. However, relationships between disability and adherence to prescribed home exercise in CLBP samples (e.g. Harkapaa et al., 1991) demonstrate that pain catastrophizing may play a role in predicting exercise behaviour in the present study.

The Coping Strategies Questionnaire (CSQ) (Rosenstiel & Keefe, 1983) and the Pain Catastrophizing Scale (PCS) have both been suggested to provide valid and reliable assessments of pain catastrophizing (Quartana, Campbell, & Edwards, 2009). However, the CSQ contains 27 items and includes assessment of coping strategies (e.g. distraction, ignoring pain, distancing from pain and praying) and only 6 items specifically assess pain catastrophizing. Although pain catastrophizing has been associated with coping throughout chronic pain literature (e.g. Leung, 2012), coping was not assessed in the present study. Therefore, the PCS was the logical choice of questionnaire as it assesses three dimensions of pain catastrophizing (i.e. helplessness, rumination and magnification) that have been shown to predict the maintenance of CLBP (Kroenke et al., 2013; Sagheer et al., 2013; Tangestani, 2012).

The PCS has been shown to be reliable and valid in mixed MSK samples including CLBP, however it has not been psychometrically evaluated in a CLBP sample alone. Osman and colleagues (2000) evaluated the PCS in a mixed pain population (including CLBP) and found internal consistency for the total PCT to be α = .92, and for the three sub-scales to be α = .95, α = .88 and α = .91 for rumination, magnification, and helplessness respectively. They also found evidence for criterion-related validity for the PCS total and sub-scales by showing that the PCS was able to differentiate between a pain and non-clinical sample ($p$ = 001). Internal consistency for the PCS in the present study was acceptable: α = .949 (PCS total score), α = .907 (helplessness sub-scale), α = .889 (rumination sub-scale) and α =.766 (magnification sub-scale).

The PCS consists of 13 items and asks participants to indicate the degree to which they have certain thoughts and feelings about their pain. The PCS assesses three dimensions of catastrophizing: rumination (4 items), magnification (3 items) and helplessness (6 items). A total score for was calculated for the 13 items, providing a general score for pain catastrophizing (range 0-52). Separate scores were calculated for the three dimensions of catastrophizing: rumination (range 0-16), magnification (range 0-12) and helplessness (0-24). Answers ranged from “not at all” (score of 0) to “always present” (score of 4), with a higher score indicating a higher level of pain catastrophizing.

### 5.5.2. Clinical Measures

Two clinical measures assessed pain (Short-form McGill Pain Questionnaire; SF-MPQ) (5.6.2.1.) and disability (Roland Morris Disability Questionnaire; RMDQ) (5.6.2.2.).

#### 5.5.2.1. **Short-form McGill Pain Questionnaire** (Melzack, 1987) (Appendix 14)

Increased pain during exercise has been associated with non-adherence to prescribed exercise in mixed MSK samples (Jack et al., 2010; Dobkin et al., 2006; Minor & Brown, 1993). However, there have been mixed results regarding the effects of pain on adherence to exercise in CLBP (Donzelli et al., 2006; Mailloux et al., 2006). Exercise programs improve outcome in CLBP (Hayden et al., 2005; Liddle et al., 2004; Sullivan, Scheman, Venesy, & Davin, 2012). Furthermore, it is recommended that the incidence of pain does not hinder someone with CLBP from carrying out their prescribed exercises (NHS, 2015; Waddell, 2004). Therefore, the present study investigates further relationships between self-reported pain and adherence behaviour in a CLBP sample.

There is no single best measure of self-reported pain (Hawker, Mian, Kendzerska, & French, 2011; Mannion, Balagué, Pellisé, & Cedraschi, 2007). The Short-form McGill Pain Questionnaire (SF-MPQ) is one of the most widely used measures of pain in chronic pain research (Wright, Asmundson, & McCreary, 2001). It has been shown to be valid (Mason, Skevington, & Osborn, 2010; Wright et al., 2001) and reliable (Georgoudis, Oldham, & Watson, 2001)

in chronic pain samples that include individuals with CLBP. Internal consistency for the SF-MPQ in the present study was acceptable: α = .858 (SF-MPQ total score), α = .788 (sensory sub-scale) and α = .797 (affective sub-scale).

The SF-MPQ questionnaire was originally developed to assess sensory and affective pain (Melzack, 1987). Since then, the sensory pain sub-scale has been found to include two separable components of sensory pain (i.e. acute sensory pain and chronic sensory pain) (Burckhardt & Bjelle, 1994), these findings were relevant to a mixed chronic pain sample of women with fibromyalgia or rheumatoid arthritis. A study assessing the SF-MPQ in a CLBP sample found no evidence of the two components of sensory pain, therefore, the questionnaire is considered in relation to the original two factor structure in the present study.

The SF-MPQ consists of 15 words describing sensory and affective dimensions of pain. The first 11 words represent the sensory dimension of pain experience (e.g. 'shooting', 'stabbing' and 'tender') and words 12-15 represent the affective dimension (e.g. 'sickening' and 'fearful'). Participants are asked to rate how much they associate each pain descriptor with their back pain based on four options; none (0), mild (1), moderate (2), and severe (3). Total score for the 15 items ranges from 0-45. Sub-scale scores for the 11 sensory items ranges from 0-33 and for the four affective items ranges from 0-12. The SF-MPQ also includes a visual analogue scale (VAS) and a present pain index (PPI). The VAS is a 10cm line that is divided into 1cm sections (ranging from 1 'no pain' – 10 'worst possible pain'). The PPI consists of 6 options evaluating overall pain intensity on a verbal rating scale (VRS) (ranging from 0 'no pain' to 'excruciating'). For each section of the SF-MPQ, a higher score indicates higher pain.

#### 5.5.2.2. **The Roland Morris Disability Questionnaire** (Roland & Morris, 1983) (Appendix 15)

Disability is a key maintaining factor of CLBP (NICE, 2009) Adherence to prescribed home exercise has been found to reduce disability in CLBP (e.g. van Middelkoop et al., 2011; Mannion et al., 2009). However, results have been inconsistent regarding the influence of disability on adherence behaviour in CLBP. For example, Harkapaa and colleagues (1991) found that higher

disability predicted better adherence to prescribed home exercise. The present study aims to investigate further relationships between disability and adherence to prescribed home exercise in a CLBP sample.

Disability can be assessed by either physical assessment or self-report. Objective physical assessments of disability are generally lower than self-reported levels of disability (Waddell & Schoene, 1998). This is posited to be due to the influence of psychosocial factors (e.g. anxiety and pain catastrophizing) on self-reported disability (Pincus & McCracken, 2013). However, it is self-reported disability that has been commonly associated with maintenance of CLBP (NICE, 2009). Therefore, self-report was deemed the most suitable assessment of disability in the present research. Objective assessment was impractical due to requiring a physiotherapist at the time of testing. Also, this would have created an additional burden for the participant in terms of time and potential concern regarding a physical assessment outside of the context of a treatment session.

Two of the most widely used self-report disability questionnaires in CLBP research are the Roland Morris Disability Questionnaire (RMDQ) and the Oswestry Disability Index (ODI; Fairbank, Couper, Davies, & O'Brien, 1980; Roland & Fairbank, 2000). Both measures were considered for use in the present study as they have been found to perform better than other measures of self-report disability that used with low back pain samples (Roland & Fairbank, 2000). The RMDQ and ODI have been compared in numerous studies investigating disability in low back pain (e.g. Newman, Stratford, Letts, & Spadoni, 2013; Davies & Nitz, 2009; Roland & Fairbank, 2000). Evidence has suggested that the RMDQ is more suitable for use with patients with mild to moderate disability, and the ODI is more suitable for patients with more severe disability (Davies & Nitz, 2009; Roland & Fairbank, 2000). However, in most cases either measure will function satisfactorily (Roland & Fairbank, 2000). Furthermore, a recent systematic review found no consistent advantage supporting the use of one measure over the other (Newman et al., 2013).

A study recruiting a CLBP sample from the same hospitals as the present research found that their sample on average displayed middle range disability scores on the RMDQ (ẋ= 11.1 out of a possible score of 24; Critchley et al.,

2007). Therefore, this information, together with high acceptability, ease of use and length of assessment of the RMDQ were considered. The RMDQ has been found to be reliable for use with CLBP populations (α = 0.89) (Foster et al., 2008; Peat, 2004). Furthermore, internal consistency for the RMDQ in the present study was acceptable: α = .83. Moreover, the RMDQ shows good construct validity when correlated against other disability measures (e.g. r=.50 with the ODI). One study found less ambiguous responses for the RMDQ compared to the ODI when investigating change over time in a back pain sample (Stratford, Binkley, Solomon, Gill, & Finch, 1994). For these reasons, the RMDQ was selected for use in the present study.

The RMDQ consists of 24 statements that people have used to describe themselves when they have back pain, for example, 'I sleep less well because of my back' and 'I avoid heavy jobs around the house because of my back'. Participants are asked to tick the statements that describe them lately, with a higher score being evidence of a higher level of disability. Final score can range from 0 (no disability) to 24 (maximum disability). Clinically significant change has been stated to be between 2 and 5 points, depending on context (i.e. clinical or research) and baseline level of disability (e.g. mild, moderate or severe) (Roland & Fairbank, 2000). For the purposes of the present research, clinically significant change was based on Patrick and colleagues (1995) suggestion of a minimum 2 to 3 point change score.

### 5.5.3. Executive function measures

Executive functions are necessary to successfully perform health behaviours, such as exercise, that involve immediate costs (e.g. increased pain) and delayed benefits (e.g. improved mobility) (Hall & Fong, 2007). Executive function deficits have been found in CLBP samples (Berryman et al., 2013; Oosterman, Derksen, van Wijck, Kessels, & Veldhuijzen, 2012; Wand et al., 2011). Therefore, it is posited by the present research that executive function deficits will predict non-adherence to prescribed home exercise in individuals with CLBP. No pattern has emerged to define areas of executive function that may be specific to individuals with CLBP (Moriarty et al., 2011). Therefore, selecting areas of executive function to examine was a challenging process. As executive function tests are developed to assess brain injured samples, it was

important to consider tests that were less likely to experience ceiling effects in a non-brain injured sample. Furthermore, an important consideration was the potential relevance of each task to prescribed home exercise.

Based on recommendations by Miyake and colleagues (2000), multiple measures were used to assess a comprehensive range of executive functions in a CLBP sample. Executive function measures included the Wechsler Test of Adult Reading (WTAR; pre-morbid IQ) (5.6.3.1), the Zoo Map test (i.e. planning ability) (5.6.4.2), the Stroop Colour-Word Interference Task (behavioural inhibition and cognitive flexibility) (5.6.3.3) and the backwards digit span test (i.e. working memory) (5.6.3.4).

#### 5.5.3.1. **The Wechsler Test of Adult Reading** (Wechsler, 2001)

Assessment of pre-morbid intelligence (IQ) is an essential part of neuropsychological evaluation (Lanham & Misukanis, 1999). However, there is no universal test of premorbid intelligence (Franzen, Burgess, & Smith-Seemiller, 1997). Methods of assessment include word reading tasks, demographic regression methods and the best performance method. A combination of these approaches is recommended for clinical use. However, the present study required a quick and accurate method of assessment. Word reading tasks are suggested to provide a practical and accurate estimate of premorbid intelligence (Schretlen, Buffington, Meyer, & Pearlson, 2005).

The National Adult Reading Test (NART; Nelson & Willison, 1982) is a widely used test of pre-morbid IQ that was considered for the present study (Bright, Jaldow, & Kopelman, 2002). However, this test has been criticised because failure to pronounce simple words correctly appeared be due to the unusual presentation of certain words (e.g. psalm and depot), rather than unfamiliarity with the word (Beardsall & Huppert, 1994). The more recent Wechsler Test of Adult Reading (WTAR) is based on the same principles as the NART, however it has not been found to share this issue (Morris, Wilson, Dunn, & Teasdale, 2005). Furthermore, the WTAR has been found to be more reliable that other word reading tasks (e.g. the Wide Range Achievement Test, WRAT; Wilkinson & Robertson, 2006) for assessment of pre-morbid IQ in individuals without brain injury (Mullen & Fouty, 2014). Therefore, the WTAR was selected as the most

current word reading test with normative data from a UK population at the time of testing.

The WTAR is based on the premise that reading is highly correlated with intelligence (Franzen et al., 1997) and that word recognition remains relatively stable in the presence of cognitive decline associated with normal aging or brain injury (Deary, 2001). The WTAR has shown concurrent validity, for example, high correlations have been found with other measures of reading (e.g. the WRAT; *r*=.73) and measures of intelligence (e.g. Wechsler Adult Intelligence Scale III Verbal Intelligence Scale; *r*=.75) (Strauss, Sherman, & Spreen, 2006). Furthermore, the WTAR has been shown to reliably estimate pre-morbid intelligence in UK samples (α=.87 - .95) (Green et al., 2008).

The WTAR can be used in combination with demographics predicted scores to predict Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997a) and Wechsler Memory Scale (Wechsler, 1997b) performance. However, the present study only required a quick and accurate assessment of pre-morbid IQ, therefore a final score was calculated based only on WTAR test data, rather than additional demographics data. The WTAR consists of 50 irregularly pronounced words read aloud from a word card (e.g. plumb, gnat, obfuscate and hyperbole). Words with irregular pronunciations were used because this allowed for assessment of previous learning of a word and minimised the current ability of the participant to apply standard pronunciation rules. Correct pronunciation of a word resulted in one point, with a maximum of 50 points available. The total score out of fifty provided an indication of intellectual function*;* with a higher score indicating higher reading ability. Final scores for the WTAR were converted to Z-score. This resulted in possible raw scores of 0 to 50 becoming a final standard score of 50 to 126 for each participant. An average standard score for a healthy sample aged 16 to 64 years is 102.9 (SD = 14.1). Although range of ages in the present sample varied slightly from this (i.e. 18 to 65 years), the average mean score of 102.9 was used due to being the closest available normative score.

#### 5.5.3.2. **The Stroop Colour-Word Interference Task** (Trenerry, 1989)

Exercise is a goal-directed behaviour that necessitates the use of executive functions, such as behavioural inhibition, in order to make effective use of

abilities that may aid successful adherence (McAuley et al., 2011; Hall & Fong, 2007). However, it is difficult to separate the concept of behavioural inhibition from other aspects of executive function for the purposes of assessment due to conceptual overlap between many domains executive function (Miyake et al., 2000). This is why a common limitation of many executive function tests is "task impurity" (Miyake & Friedman, 2012). Nevertheless, of the numerous tests that are alleged to assess behavioural inhibition in addition to multiple other domains of executive function (e.g. the Tower of Hanoi and the Wisconsin Card Sorting Test), two tests have been argued to predominantly assess behavioural inhibition. These two tasks are the traditional Stroop Colour-Word Interference Task and the Stop Signal (SS) task (Aron, 2007; Nee, Wager, & Jonides, 2007). However, low correlations between the two tasks have led researchers to suggest that the tasks are influenced by different underlying processes (Khng & Lee, 2009).

The assessment of behavioural inhibition in CLBP is a relatively recent occurrence (Wand et al., 2011). For this reason, it may be argued that there is not enough research to provide a detailed understanding of specific processes that underlie behavioural inhibition CLBP. Together with problems of task impurity, this led to difficulties relying on one test to effectively assess behavioural inhibition in the present research. Therefore, task selection was based on measures that have shown deficit in previous CLBP samples. This provides data that are easily comparable across studies. Furthermore, this allows findings from the present research to build on present available data regarding behavioural inhibition in CLBP.

The Stroop colour-word task has been used to assess behavioural inhibition in a mixed chronic pain sample (62% chronic MSK pain) (Oosterman et al., 2012). Furthermore, a Stroop colour-word task has also been used to assess relationships between behavioural inhibition and exercise behaviour in older adults (McAuley et al., 2011). Modified emotional Stroop tasks have demonstrated poor executive functioning in CLBP samples (e.g. Roeloffs et al., 2003; Crombez et al., 2000).

However, although the modified emotional Stroop task is posited to assess behavioural inhibition, it is argued to predominantly assess attentional bias to

pain-related stimuli. The present research intended to investigate behavioural inhibition as a primary mechanism that may explain exercise adherence behaviour, based on the notion that successful behavioural inhibition is required to successfully perform a health behaviour that involves immediate costs and delayed benefits (McAuley et al., 2011; Hagger et al., 2002; Hall & Fong, 2007). Therefore, the modified emotional Stroop task was not considered a suitable option. Furthermore, lack of psychometric data for the modified emotional Stroop test led to questions regarding its reliability and validity (Dear, Sharpe, Nicholas, & Refshauge, 2011; Cisler et al., 2009).

The present study selected a validated and reliable version of the Stroop colour-word interference test (Trenerry, 1989) to primarily assess behavioural inhibition in relation to adherence to prescribed home exercise in a CLBP sample. Findings are referred to in terms of behavioural inhibition, however it is acknowledged that the Stroop test may also assess aspects of attentional bias (Oosterman et al., 2012; Cisler et al., 2009), set-shifting (also known as task switching) (Stemme et al., 2007), cognitive flexibility (Uttl & Graf, 1997), interference (Kravariti et al., 2009; Stroop, 1935) and general executive functioning (Zalonis et al., 2009; Moering et al., 2004). The Trenerry (1989) version of the Stroop test has displayed good test-retest reliability in a sample of people without brain injury (.90). Furthermore, it has shown to be able to discriminate between those with brain injury and those without brain injury by using only the colour-word score ($p$<.001). Moreover, the test correlates well with other indices of executive function, for example, the Wechsler Adult Intelligence Scale-Revised (WAIS-R) full scale IQ (Wechsler, 1981; r = .46), verbal IQ ($r$ = .44) and performance IQ ($r$ = .50).

The Stroop Colour-Word Interference test requires two tasks to be administered to participants. Participants are given 2 sheets of colour words, each printed in discordant coloured ink (i.e. the word *green* is never printed in *green* ink). The first task (colour task) requires the participant to read the words aloud. This primes them for the next task (colour-word task) where participants are asked to name the colour of the ink in which the words are printed (e.g. the word *blue* is written in *red* ink). Previous experience tells the participant that the meaning of a word is more important than the colour and so the interference effect occurs when attention is focused on the colour. The score is calculated as the number

of correct responses in 120 seconds, where a high number of correct responses indicates low interference and low attentional bias. Only the score from the colour-word task is used for statistical analyses. The more time spent naming the colour of a word, the larger the attentional bias. Cut-off scores identifying the presence of executive function deficits are 98 (age 18-49 years) and 61 (> 50 years) (Trenerry, 1989). Average normative scores in a healthy sample are 104.9 (SD 10.22) for individuals aged 18-49 years and 93.98 (SD 18.41) for individuals aged ≥ 50 years.

#### 5.5.3.3. **The Zoo Map Test** (Wilson et al., 1997)

Adherence to exercise requires deliberate planning prior to the initiation of the exercise behaviour itself (McAuley et al., 2011; Hagger et al., 2010). Planning requires the ability to organise behaviour according to a sequence of steps in order to carry out a course of action (Owen, 1997; Luria, 1978). One of the most widely used executive function tests of planning is the Tower of London (ToL) test (Shallice, 1982; Kaller, Unterrainer, Rahm, & Halsband, 2004). The ToL test involves the manipulation of beads on wooden pegs in an attempt to match a configuration of beads shown in a picture. However, the nature of the ToL test has led to questions regarding its ecological validity (Phillips, Kliegel, & Martin, 2006). Furthermore, functional magnetic resonance imaging (fMRI) scans have shown that brain activity associated with planning is modulated by the ecological validity of the measure used to assess planning (Campbell et al., 2009). Thus, tests that accurately reflect real-life are recommended to provide more accurate assessments of planning ability (Grewe et al., 2013; Campbell et al., 2009). The Porteus Maze Test (PMT) (Porteus, 1965) and the Zoo Map test are tests of planning that are considered to display ecological validity (Rizzo, Reinach, McGehee, & Dawson, 1997; Wilson et al., 1997). Both tests provide participants with a map and ask them to follow certain rules in order to plan a route that leads to an exit point. However, the Porteus maze test can take between 15 and 60 minutes to complete, and therefore was not suitable in the case of the present research where time was a primary concern. Therefore, the Zoo Map test was selected to assess planning ability in the present study.

The Zoo Map test is part of the Behavioural Assessment of Dysexecutive Syndrome (BADS) battery of tests and assesses both formulation and execution

of a plan (Wilson et al., 1997). The BADS tests have been argued to assess executive functioning in complex, real-life situations and to successfully predict day-to-day difficulties (Norris & Tate, 2000; Wilson & MacLeod, 2003; Wilson et al., 1997) Inter-rater reliability for the Zoo Map Test is high (r=.90). Regarding validity, the BADS tests have been found to have good face validity due to being more practical than other tests of planning (Wilson & MacLeod, 2003). Construct validity of the BADS is comparable to other tests of executive function, and the Zoo Map Test in particular is able to differentiate between a sample of people with brain injury and those without brain injury (Norris & Tate, 2000). The Zoo Map has also found to correlate with other tests of planning (e.g. the Porteus Maze Test, $r$ = -.41) (Norris & Tate, 2000). The BADS and its sub-tests have not been used in a sample of people with CLBP, however the Zoo Map Test has recently been used in a mixed chronic pain sample where no deficits were found in planning ability (Oosterman et al., 2012).

The Zoo Map Test assesses the ability to plan in advance, problem solve and to organize priorities in the face of two or more competing tasks. There are two parts to the test. First, formulation of a plan requires the development of a strategy to decide how to achieve a specific goal. Second, execution of a plan requires the ability to monitor and guide the execution to successfully achieve this goal. This can be translated into the sequence of events that a person may have to follow in order to plan and accomplish prescribed exercises and activities. This also provides evidence of “task impurity” (Miyake & Friedman, 2012) where the Zoo Map test is likely to assess numerous executive function abilities related to planning (e.g. decision making and problem solving) (Salthouse & Siedlecki, 2007).

The test consists of a high demand and a low demand trial. In both trials, the participant is required to follow rules when planning to visit specific locations (e.g. the elephant house and the crocodile pit) on a map of a zoo. The first (high demand formulation condition) trial requires that the participant plans a route in advance to be able to visit all of the locations specified in the instructions. When planning their route they must follow specific rules (e.g. ‘you may take only one camel ride’). The second (low demand execution condition) trial requires the participant to visit the same locations in a specified order. In both tasks, when planning the route, the same rules must be obeyed. Errors are subtracted from

a raw score (0 or less to 8) for each of the two trials. These are summed and then converted to a final score of 0 to 4. A higher score indicates better planning ability. Mean normative score for the Zoo Map test is 2.44 (SD=1.13).

#### 5.5.3.4. **Wechsler Memory Scale III – Digit span** (Wechsler, 1997b)

Research investigating working memory in CLBP has reported mixed results. For example, Shuchang and colleagues (2011) found no evidence of working memory deficit in a CLBP sample, whereas three studies have found evidence of poor working memory in CLBP (Wesnes & Annas, 2012; Jorge et al., 2009; Dick & Rashiq, 2007). Relationships between working memory and exercise adherence behaviour has rarely been assessed. A recent study that did assess these relationships in older adults found no association between working memory and adherence behaviour (McAuley et al., 2011). However, McAuley and colleagues (2011) used the Wisconsin Card Sorting Test (WCST) to assess working memory in their study. The WCST has been found to assess numerous domains of executive function, however working memory has been found not to be related to assessment using the WCST (Stratta et al., 1997). In addition, working memory has not been investigated in a CLBP sample in relation to exercise adherence behaviour.

Working memory tests require an individual to hold information in their mind while performing a mental process of some kind (Lezak, 2004). Measures to assess working memory that have been used in studies with CLBP samples include the Wechsler Memory Scale III (WMS-III, Wechsler, 1997 in Jorge et al., 2009) the WHO Neuro-behavioural Core Test battery (Letz, as cited in Shuchang et al., 2011), the CDR computerized assessment system (Keith et al., 1998 in Wesnes & Annas, 2012) and the spatial span test (Shah et al., 1996 in Dick & Rashiq, 2007). However, a recent systematic review found that overall, the WMS-III digit span is the most commonly used test for assessing working memory in chronic pain samples (Berryman et al., 2013). Furthermore, the WMS-III digit span test has shown good test-retest reliability (.5 - .7) and high internal reliability (.9 - .9) (Conway et al., 2005).

The digit span test consists of two sub-tests, the forward (FW) and backward (BW) digit span. The FW and BW digit span are considered to assess different cognitive constructs, however, these constructs are ill defined (Choi et al.,

2014). The FW digit span is believed to assess attention and short-term memory (Groth-Marnat & Baker, 2003) and the BW digit span is believed to assess working memory (Hill et al., 2010; Canali, Brucki, & Bueno, 2007; Lezak, 2004; Choi et al., 2014). In the present study, working memory is the topic of interest and therefore only the BW digit span test is used for scoring purposes. The BW digit span assesses working memory by rating how much information can be attended to at one time while recalling a string of numbers and repeating them backwards. At the beginning of the test participants are given a sequence of three numbers (FW) or two numbers (BW) that they asked to repeat back to the examiner. The sequence of numbers gradually increases up to nine digits (FW) or eight digits (BW) or until two incorrect answers are given. Participants are asked to repeat the first set of numbers forwards and the next set of numbers backwards. The more numbers a participant can recall for the BW digit span, the greater their working memory ability.

It is difficult to provide normative data for the BW digit span for two reasons. First, the WMS-III test manual suggests that the digit span test is scored by combining the total number of correct digit strings in the FW and BW condition. However, as the present study wishes only to assess working memory, this scoring procedure is not suitable. Second, normal scores cited by different researchers for the BW digit span are varied. For example, a normal score is claimed to range from 7 – 9 (McKeon, 2015) or 4 – 5 (Lezak, 2004) depending on what literature is consulted. Research investigating working memory using the BW digit span in healthy samples has found average scores of 6.0 (SD=1.3) (Woods et al., 2011) and 8.03 (SD=2.34) (Hill et al., 2008). However, samples in both studies were young ($\dot{x}$=26 years and $\dot{x}$=20 years respectively). Therefore, although these may be useful reference scores, they are not entirely generalisable for use in the present study recruiting a wider age range of participants (18-65 years). Scoring differences in studies investigating working memory using a combined score for the FW and BW digit span tests, mean that normative data from these studies cannot be used for comparison purposes (e.g. Shuchang et al., 2011; Hill et al., 2010).

### 5.5.4. Exercise adherence behaviour as the primary outcome

Exercise adherence behaviour was the primary outcome for Study 3. The assessment of exercise adherence behaviour using triangulation of adherence measures are suggested to increase the reliability of results compared with using a single method of measurement (Tenenbaum & Eklund, 2012; World Health Organisation, 2003). Objective measures of exercise adherence behaviour found unsuitable for use in the present study due to the inability of such measures to assess the types of exercises prescribed for CLBP (Bollen et al., 2014).Therefore, adherence behaviour was assessed using three self-report measures. Firstly, adherence behaviour was assessed using the Exercise Adherence Rating Scale (EARS). Second, participants were asked how often they were doing their exercises compared to how often they were asked to exercise. Lastly, physiotherapists completed the Sports Injury Rehabilitation Adherence Scale (SIRAS; Brewer et al., 2000).

The EARS has been described in detail in a previous chapter describing the development and psychometric evaluation of the EARS (Chapter 4). Therefore, the EARS is only briefly described in the current section (5.6.4.1). The SIRAS is discussed next as an additional assessment of adherence behaviour (5.6.4.2).

#### 5.5.4.1. The EARS (Appendix 4b)

The EARS is a 6-item measure assessing adherence to prescribed home exercise recommended by a healthcare provider. When completing the EARS, participants are asked to tick a box that best describes how they do their recommended exercises/activities. Each statement is scored on a 5-point Likert scale (0 - completely agree to 4 - completely disagree), resulting in a possible score of between 0 and 24. A higher score indicates better adherence. Initial psychometric evaluation of the EARS found that the six adherence items formed a unidimensional scale that showed good measurement properties, including acceptable internal consistency ($\alpha = 0.758$) and high test-retest reliability [ICC = 0.97 (0.94 – 0.98)].

In addition to assessment of adherence using the EARS, the Prescribed Exercise Questionnaire (PEQ) (Appendix 4a) asked participants how often they have been asked to exercise and how often they are exercising at the present

time. In order to provide additional information regarding reasons why participants do or do not exercise, they were asked to complete 10 questions asking what hinders or helps their adherence to prescribed exercise (Appendix 4c).

#### 5.5.4.2. **The SIRAS** (Appendix 7)

Additional assessment of adherence behaviour was provided by physiotherapists using the Sport Injury Rehabilitation Adherence Scale (SIRAS; Brewer et al., 2000). The SIRAS is a reliable and valid measure that was developed to assess adherence to treatment within physiotherapy sessions or adherence to exercise completed outside of physiotherapy sessions (Kolt et al., 2007). Physiotherapists are asked to complete three questions regarding patient adherence behaviour. Questions refer to intensity with which participants completed their exercises, frequency with which the patient followed their instructions or advice and how receptive they felt their patient was to changes in the rehabilitation programme. Answers were scored on a 5-point Likert scale ranging from 1 (not adherent) to 5 (very adherent). The three questions are summed resulting in a total score ranging from 3 to 15, with a higher score indicating better adherence.

## Chapter summary

This chapter introduced the methods and measures selected for a study investigating non-adherence to prescribed home exercise in CLBP. Design and procedures for conducting the research were discussed, including description of treatments that participants underwent as part of routine physiotherapy practice. Participants attended either individual 1:1 physiotherapy sessions or group back classes or both. A back rehabilitation class and dynamic control class were described and details of prescribed home exercises for all treatments were provided. After acknowledging issues affecting selection of measures (e.g. participant burden, disadvantages and advantages of self-report and issues of reliability and validity) (Chapter 2), a battery of psychosocial, clinical and executive function tests was developed. Adherence was the primary outcome and was assessed using the Exercise Adherence Rating Scale. Additional assessment of adherence behaviour was provided by physiotherapists using the Physiotherapist Home Exercise Adherence Rating Scale. Psychosocial variables selected for investigation included general health status, social support, mood (i.e. anxiety and depression), illness perceptions, fear-avoidance beliefs and pain catastrophizing. Pain and disability were assessed as clinical variables. Executive function variables were pre-morbid IQ, behavioural inhibition, planning ability and working memory. The next chapter presents baseline results for this study (Chapter 6). Follow-up results are presented in a subsequent chapter (Chapter 7).

# 6. Study 3: Baseline Methods of Analyses and Results

## 6.1. Overview

This chapter discusses the baseline methods of analysis and results for Study 3. This chapter consists of five main sections. Firstly, there is a brief summary of methods and procedure conducted to collect baseline data (6.1.). Methods of analysis for baseline data are then described (6.2.). Subsequent to this, discussion focuses on the results of baseline data analyses (6.3.). There is next a discussion of baseline data findings in relation to existing CLBP and MSK research literature (6.4.). Lastly, there is a summary of baseline findings (6.5.). Methodological considerations, clinical and research implications of Study 3 are discussed in relation to baseline and follow-up findings in the next chapter (Chapter 7).

## 6.2. Baseline data collection methods and procedure

The third research objective of this thesis refers to baseline data analyses for Study 3 (6.2.1.). Baseline methods and procedure are discussed in detail in the research protocol for Study 3 (Chapter 5). However, methods and procedures are briefly summarised here for purposes of clarity (6.2.2.). Participant inclusion and exclusion criteria are then reiterated (6.2.3.). Baseline data collection procedure is stated next (6.2.4.). Psychosocial, clinical and executive function baseline measures are listed subsequent to this (6.2.5.). Finally, discussion focuses on baseline participant recruitment and flow for the study (6.2.6.).

### 6.2.1. Research Objective 3

The baseline data research objective is to assess and examine relationships between psychosocial, clinical and executive function factors in individuals with CLBP.

### 6.2.2. Baseline methods and recruitment

This was a prospective, observational study. Methods and procedure are described in full in the previous chapter (Chapter 5), but are briefly repeated here. Participants were recruited from physiotherapy departments at Guy's and St. Thomas' Hospitals (GSTT) and King's College Hospital (KCH) using

opportunistic sampling methods. Patients with physiotherapy triage appointments were accessed by the researcher using Patient Management Software (PMS). Referral letters for all patients were then accessed using Electronic Patient Records (EPR) software. Those who were referred for musculoskeletal problems due to CLBP (or LBP with no stated duration) were posted an invitation letter (Appendix 5) and information sheet (Appendix 1) about the study. Patients were phoned after their triage session and asked if they were interested in participating in the study. At that point, participants who wished to participate were screened over the phone to check that they satisfied inclusion criteria for entry into the study. Eligible participants were asked if they were willing to arrive 1 hour before their first physiotherapy appointment.

### 6.2.3. Participant inclusion and exclusion criteria

Eligible patients were aged 18-65, had non-specific CLBP of 3 months or more, were prescribed home exercises as part of their treatment and were fluent in written and spoken English. Age range was restricted to control for potential confounding factors that would otherwise bias the results of the study (i.e. age-related cognitive decline and age-related co-morbid illness). Patients were excluded if they were unable to give consent, had specific CLBP (e.g. due to infection, tumour, osteoporosis or fracture), had neurological, psychiatric or intellectual disturbances, or were colour blind or had very poor eyesight.

### 6.2.4. Baseline procedure

Baseline assessment was carried out in person in a quiet room in the appropriate physiotherapy department. Assessment occurred prior to start of treatment. Psychosocial, clinical and executive function measures were completed, together with a demographics questionnaire and informed consent.

### 6.2.5. Baseline measures

In brief, single-item measures were used to assess general health status and duration of pain. Psychosocial measures assessed social support (single-item measure), mood (Hospital Anxiety and Depression Questionnaire; HADS), illness perceptions (Brief Illness Perceptions Questionnaire; Brief IPQ), fear-avoidance beliefs (Fear-avoidance Beliefs Questionnaire; FABQ) and pain catastrophizing (Pain catastrophizing Scale; PCS). Clinical measures assessed

pain (Short-form McGill Pain Questionnaire; SF-MPQ) and disability (Roland Morris Disability Questionnaire; RMDQ). Executive function measures assessed pre-morbid IQ (Wechsler Test of Adult Reading; WTAR), planning ability (the Zoo Map test), behavioural inhibition (the Stroop Colour-Word Test; the Stroop test) and working memory (backwards digit span test; BW digit span).

### 6.2.6. Baseline participant recruitment and flow

This section describes participant recruitment based on the sample size calculation presented in the research protocol for Study 3 (Chapter 5) (6.2.6.1.). A flow diagram provides a visual representation of baseline participant progress (Figure 7). Next, discussion focuses on participant flow (6.2.6.2.).

#### 6.2.6.1. Participant recruitment

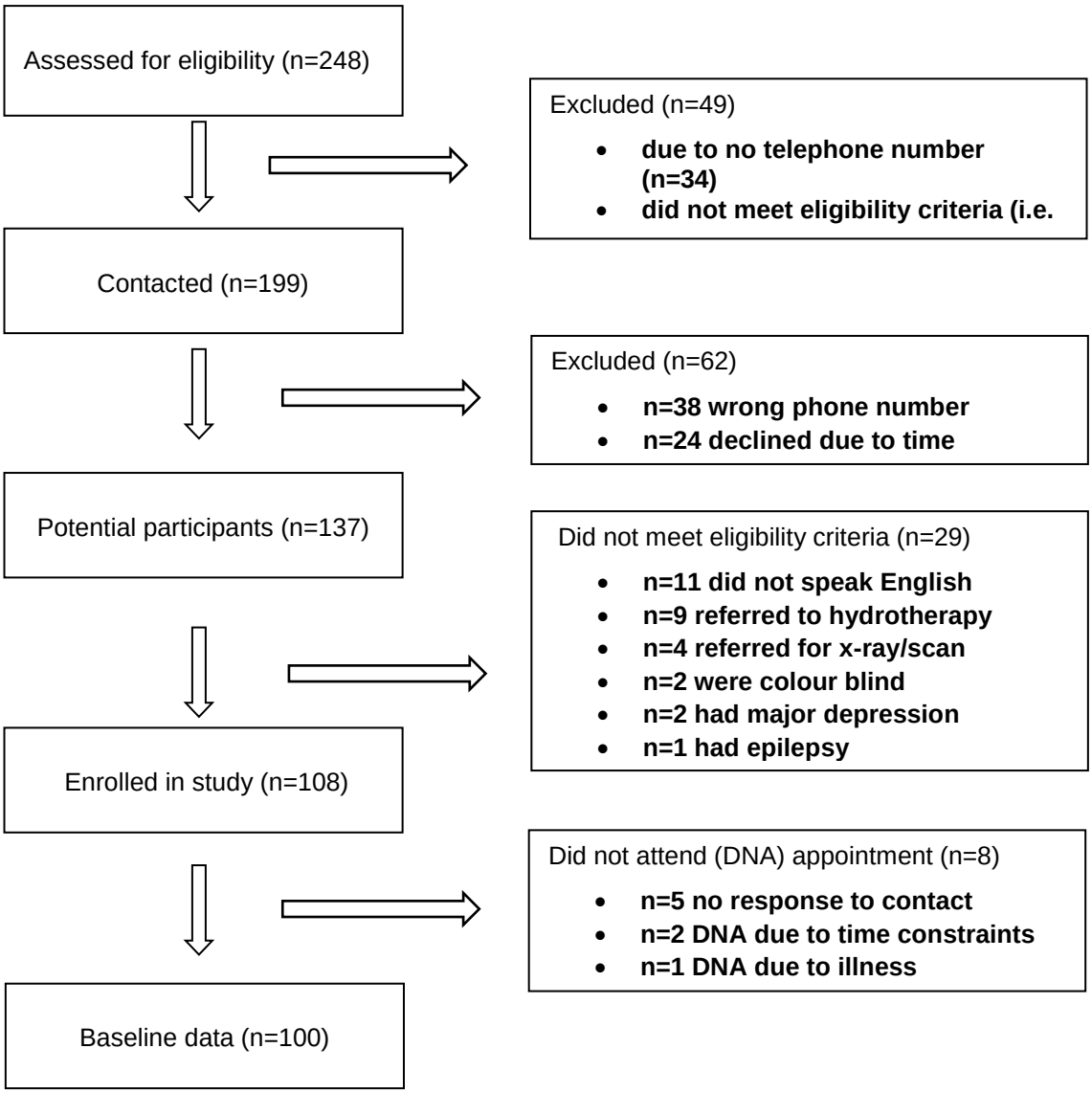
According to the sample size calculations, 152 participants were needed at baseline allowing for a 20 percent attrition rate (Tabachnick & Fidell, 2007). Approximately 200 new patients with CLBP are referred to GSTT and KCH each month and previous research suggests that 50% of these would be eligible for this study (Critchley et al., 2007). Together with advice from physiotherapists regarding numbers of patients expected to attend daily triage sessions, it was estimated that approximately 4 patients per week with CLBP could be recruited if triage sessions were attended 4-5 days per week. It was estimated that recruitment would take 44 consecutive weeks (approximately 10 months). However, factoring in weeks where fewer participants may be recruited or fewer sessions may be attended by the researcher, 66 weeks (15 months) were set aside to complete baseline data collection for 175 participants at a rate of 2 to 3 per week (11 to 12 per month).

Triage sessions were held daily at all three sites. Larger triage sessions ran at Guy's Hospital on Tuesdays and Thursdays and at St. Thomas' Hospital and KCH on Thursdays and Fridays. The researcher aimed to attend mainly the larger triage sessions to increase recruitment opportunities. During the first 3 months of recruitment it became evident that recruitment rates were slower than expected (n=21). Reasons for this included lack of contact details and wrong contact details for patients at GSTT. This was not the case at KCH where patients were asked via letter to contact the physiotherapy department to

update their personal details prior to their telephone triage appointment. However, for patients at GSTT, all contact prior to their triage appointment was done via letter, therefore a correct telephone number was not yet required. Patients at GSTT were asked to update their contact details at their triage appointment, however this was clearly not done by some patients or updated information was entered incorrectly. A flowchart showing participant progress throughout the study, including further reasons for non-participation in the study, is shown in Figure 7.

In an attempt to increase recruitment rate, a meeting was arranged with the assistant service manager for the musculoskeletal team at GSTT. This resulted in information about a system where 'problem cases' (e.g. those potentially in need of surgery) were referred directly to triage in the orthopaedic departments for their first session, thus bypassing the usual physiotherapy department triage system. A system was developed where the assistant service manager would provide a list of these patients on a weekly basis (from January 2012) and the researcher could then access their referral information on PMS. Although patients referred for surgery were excluded from the study, some of these patients were referred on to the physiotherapy department. These patients bypassed the physiotherapy triage system and therefore their information was not accessible to the researcher. Even with the additional patient lists, recruitment rate remained the same and it became evident that recruitment was likely to remain slower than predicted. With this in mind, it was decided that baseline data collection would have to be completed by May 2013 in order for follow-up data to be collected within the given time constraints. Therefore, baseline data collection ran over a period of 19 months (October 2011 to May 2013), with a final sample of 100 participants (Guy's Hospital, n=71; St. Thomas' Hospital, n=12; KCH, n=17).

**Figure 7.** ***Flow diagram of baseline participant progress for Study 3***



#### 6.2.6.2. Baseline participant flow

Figure 7 shows participant flow throughout baseline recruitment for Study 3. Initially, 248 patients with CLBP were accessed on PMS prior to their triage appointment. One hundred and eleven (49+62) of these patients were excluded from the study due to age (>65 years), having no contact number, having the wrong contact number or declining to participate due to time constraints. This resulted in 137 participants, 29 (21%) of which were excluded due to eligibility criteria resulting in 108 participants. This is less than the approximately 30 percent of participants that were expected to be excluded due to eligibility criteria in the present study. The expected percentage of exclusion was based on figures extracted from a study that recruited CLBP patients from the same hospitals as the present study (Critchley et al., 2007). Critchley and colleagues (2007) used similar inclusion and exclusion criteria as the present study and excluded 29 percent of participants due to eligibility criteria. Of the 108 participants who agreed to participate, eight did not attend their appointment to complete baseline measures, resulting in a final sample of 100 participants.

## 6.3. Methods for baseline data analyses

This section describes methods used for baseline data analysis. Firstly, descriptive statistics, including methods of preliminary analyses, are discussed (6.3.1.). Discussion then focuses on cross-sectional and correlational methods of analyses used to examine relationships between psychosocial, clinical and executive function factors (6.3.2.). Lastly, there is discussion of methods used to evaluate baseline missing data within and across observed measures (6.3.3.).

### 6.3.1. Descriptive statistics and preliminary analysis

Data were entered into SPSS version 20. Prior to analyses, data were screened and assumptions of normality were tested. Frequencies and descriptive statistics (means and SDs) were performed on the data to check for unusual values and any found were checked with original data and data entry errors were corrected. A combination of visual inspection and assessment using skewness and kurtosis were used to assess normality. Values of skewness and kurtosis between -2 and +2 were considered acceptable (George, 2010). It was

decided that any non-normal variables would not be normalised using log transformation, due to log transformation changing the units of the variable, leading to problems interpreting results. Bootstrapping was considered the preferred solution for any non-normally distributed variables that may be included in subsequent analyses. Bootstrapping does not rely on assumptions of normality and can provide more accurate inferences when sample size is smaller than required (Field, 2009).

### 6.3.2. Cross-sectional and correlational analyses of baseline data

The third research objective was to assess and examine psychosocial, clinical and executive function factors at baseline (i.e. prior to physiotherapy treatment) in a sample of adults with CLBP. This objective consisted of two components. First, cross-sectional analysis allowed for the comparison of the CLBP sample to normative data and other CLBP samples. These are described as comparisons that were external to the CLBP sample. Second, correlational analysis provided insights into relationships between psychosocial, clinical and executive function factors in CLBP. These are described as internal comparisons.

Baseline differences were assessed between the present CLBP sample and normative samples and comparison CLBP samples where data were available (i.e. external comparisons). The comparison samples were identified based on similarities to the present sample (i.e. locational and demographic similarities and duration of pain). Therefore, for most variables, a different CLBP sample was used to compare each variable. Mean baseline scores were compared using one-sample t-tests for normally distributed continuous data. Means, standard deviations, *p* values and Cohen's *d* ES are provided. Cohen's $U_3$ was estimated to indicate the percentiles at which the present CLBP sample and any compared sample overlap (i.e. to explain the percentage of one sample that would be above the mean of the comparison sample). Pearson's product-moment correlations (r) were used to assess the strength of relationships between baseline scores of independent variables (i.e. internal comparisons). See Chapter 2 for explanations of ES (d and r) and Cohen's $U_3$.

### 6.3.3. Baseline missing data analyses

Baseline missing data were evaluated for individual observed measures (i.e. within questionnaires) and across baseline observed measures (i.e. cross-sectionally between questionnaires). There is no definitive test of missing data. However, certain analyses can provide information to ensure that assumptions about type of missing data are not clearly violated. MVA provided information about the amount of missing data, where the missing data were located and whether or not data could be considered missing completely at random (MCAR). Where missing data were more than five percent for a single observed variable, separate variance t-tests were calculated to investigate the likelihood of this data to be MCAR. The further the t-value from ± 2, the greater the departure from randomness and the less likely the data were to be MCAR. Little's MCAR test was calculated as a further evaluation of the MCAR assumption. The null hypothesis for this test is that missing data are MCAR. Therefore, a non-significant *p* value (i.e. $p \geq .5$) constitutes a failure to reject the null hypothesis and an indication that the data could potentially be MCAR. However, a non-significant *p* value does not imply sufficient evidence to support the null hypothesis and Little's MCAR test is not sufficient to confirm the data MCAR.

Once it was decided which missing data mechanism was most likely to fit the data (i.e. MCAR, MAR or MNAR), subsequent analyses accounted for this. This is because violation of any of these assumptions can lead to biased parameter estimates and standard errors, thus invalidating results to some extent. If data were decided likely to be MCAR, listwise deletion was considered an acceptable approach for further analyse. However, researchers can rarely be certain that data are MCAR. Therefore, a sensitivity analysis was proposed to aid investigation of the likely missingness mechanism by exploring how results varied under MCAR (i.e. listwise deletion) and MAR (i.e. multiple imputation, MI) assumptions.

## 6.4. Baseline results

This section presents results of baseline data analyses for Study 3. First, results of preliminary data checks are described (6.4.1.). Second, discussion focuses on characteristics of the 100 baseline participants (6.4.2.). Third, missing data is

investigated within and between baseline questionnaires (6.4.3.). Then, mean scores for the CLBP sample from the present study are compared to normative samples and other CLBP samples for variables assessed at baseline (6.4.4.). Next, correlational analysis explores relationships between psychosocial, clinical and executive function factors in CLBP (6.4.5.).

### 6.4.1. Participant characteristics

The mean age of participants was 39 years (range 19 to 65 years; SD 11.9) and 76 percent were female. Sixty-five percent of participants were from any white background, 11 percent were African or Caribbean British, 5 percent were Asian or Asian British and 9 percent were from mixed backgrounds. Six percent of participants had received no formal education, 37 percent had GCSE or A-levels and 49 percent were of university or graduate level. Seventy-one percent of the sample were employed or self-employed, 11 percent were unemployed, and 18 percent were retired or students. Participants had CLBP for an average of 6.2 years (range 3 months to 30 years; SD 6.1). Sixty-three percent of participants had CLBP for between 3 months and 5 years. Eight percent of participants had CLBP for 10 years, 4 percent for 16 years, 4 percent for 20 years, 1 percent for 25 years and 1 percent for 30 years. Participants stated that their general health was either excellent (10%), very good (32%), good (36%), fair (19%) or poor (3%). The 1-item social support question is included in this section as it is not a validated questionnaire and there are no comparison data. When asked if there was someone to give them good advice about a problem, 78 percent of participants answered ‘yes’.

### 6.4.2. Descriptive statistics

This section describes preliminary data checks done prior to main analyses (6.4.2.1.). Data were screened and assumptions of normality were tested. Subsequent to this, frequencies and descriptive statistics (means and SDs) were performed on the data (6.4.3.).

#### 6.4.2.1. Preliminary analysis

Histograms for each variable showed no obvious deviations from normality. Values of skewness and kurtosis between -2 and +2 were considered

acceptable (George, 2010). Based on this rule, all except one variable (the Zoo Map test 'execution') were approximately normally distributed. The Zoo Map test 'execution' variable was found to have high skewness (-2.24, *SE* = .25) and high kurtosis (4.12; *SE* = .49). Bootstrapping was considered for subsequent analysis including this variable.

### 6.4.3. Summary of scores for baseline variables

Table 14 provides means, standard deviations and effect sizes of baseline variables compared to normative data and comparison CLBP data. Both types of data were provided when they were available, for example, there is no normative data for questionnaires that ask about issues related to chronic illness. This is because a 'normal' sample may be asked to imagine suffering from a chronic condition or an acute variation of a chronic condition, providing data that is not comparable to individuals with chronic conditions. CLBP samples from UK populations with a similar age range were sought for comparison purposes. However, the search was not systematic, therefore results of the selected comparison studies cannot be generalised to individuals with CLBP in general. Where comparison CLBP data from a non-UK sample was not available, this has been stated beneath Table 14. For one variable, the Brief IPQ, there are no data from a CLBP sample. Therefore, a mixed (80%) CLBP and sub-acute CLBP sample were used for comparison purposes (Løchting, Garratt, Storheim, Werner, & Grotle, 2013). Baseline variables are discussed in two sections; the present CLBP sample versus normative samples (6.4.3.1.) and the present CLBP sample versus other CLBP samples (6.4.3.2.). Subsequent to this, findings regarding baseline comparisons are summarised (6.4.3.3.).

**Table 14.** ***Means and standard deviations of baseline variables compared to normative and comparison data***

| Baseline Variable | N | ẋ (SD) | Norm.ǂ ẋ (SD) | Test and *p* value | Comp.ǂ ẋ (SD) | Test, *p* value and ES |
|---|---|---|---|---|---|---|
| ***Psychosocial Variables*** | | | | | | |
| **HADS** | | | | | | |
| Anxiety | 98 | 7.8 (4.0) | 6.1 (3.8)[1] | t = 4.19<br>p = .000<br>d = .44 | 9.0 (4.1)[2] | t = -3.02<br>p = .003<br>d = -.30 |
| Depression | 98 | 5.3 (3.5) | 3.7 (3.1)[1] | t = 4.56<br>p = .000<br>d = .48 | 7.4 (4.4)[2] | t = -5.82<br>p = .000<br>d = -.53 |
| Total Distress | 98 | 13.1 (6.7) | 9.8 (6.0)[1] | t = 4.78<br>p = .000<br>d = .52 | - | - |
| **Brief IPQ** | | | | | | |
| Consequences | 97 | 6.3 (2.2) | - | - | 6.2 (2.2)[3] | t = .352<br>p = .726<br>d = .05 |
| Timeline | 97 | 6.8 (2.5) | - | - | 7.4 (2.4)[3] | t = 8.45<br>p = .000<br>d = -.25 |
| Personal control | 97 | 5.6 (2.6) | - | - | 4.7 (2.1)[3] | t = 3.44<br>p = .001<br>d = .38 |
| Treatment control | 97 | 3.3 (2.2) | - | - | 3.3 (2.4)[3] | t = -.367<br>p = .715<br>d = 0 |
| Identity | 97 | 6.7 (2.1) | - | - | 5.8 (2.0)[3] | t = 4.13<br>p = .000<br>d = .44 |
| Concern | 97 | 8.0 (2.0) | - | - | 5.5 (2.7)[3] | t = 12.34<br>p = .000<br>d = 1.05 |
| Coherence | 97 | 4.7 (2.8) | - | - | 3.3 (2.6)[3] | t = 5.08<br>p = .000<br>d = .52 |
| Emotional representation | 97 | 6.3 (2.4) | - | - | 5.5 (2.6)[3] | t = 3.22<br>p = .002<br>d = .32 |
| Total Brief IPQ | 97 | 47.7 (11.4) | - | - | 52.0 (13.0)[3] | t = -3.76<br>p = .000<br>d=-.35 |

| Baseline Variable | N | ẋ (SD) | Norm.[1] ẋ (SD) | Test and *p* value | Comp.[1] ẋ (SD) | Test, *p* value and ES |
|---|---|---|---|---|---|---|
| **FABQ** | | | | | | |
| Exercise | 96 | 14.0 (5.0) | - | - | 16.5 (5.6)[2] | t = - 4.9<br>p = .000<br>d = -.47 |
| Work | 95 | 16.8 (10.3) | - | - | 20.6 (12.4)[2] | t = -3.58<br>p = .001<br>d = -.33 |
| **PCS** | | | | | | |
| Helplessness | 98 | 7.2 (5.5) | | | - | - |
| Magnification | 98 | 3.7 (2.6) | | | - | - |
| Rumination | 98 | 6.0 (4.2) | | | - | - |
| Total PCS | 98 | 16.9 (11.6) | | | 18.1 (10.6)[4] | t = -1.07<br>p = .286<br>d = -.12 |
| ***Executive Function Variables*** | | | | | | |
| **WTAR** | 94 | 105 (11.9) | 102.9 (14.1) | t = 1.71<br>p = .089<br>d = .16 | - | - |
| **Stroop Test[H] (18-49 years)** | 76 | 101.9 (10.7) | 104.9 (10.2) | t = -2.49<br>p = .015<br>d = -.58 | - | - |
| **Stroop Test[H] (50-65 years)** | 18 | 81.2 (14.1) | 93.9 (18.4) | t = -3.81<br>p = .001<br>d = -1.85 | - | - |
| **Zoo Map Test** | | | | | | |
| Formulation of plan | 96 | 3.0 (2.8) | - | | - | - |
| Execution of plan | 96 | 7.0 (2.1) | - | | - | - |
| Total Zoo Map Test | 96 | 2.1 (1.2) | 2.44 (1.1) | t = 2.63<br>p = .01<br>d = -.30 | | |
| **BW digit span** | 92 | 5.7 (1.8) | 6.0 (1.3)[7] | t = -1.79<br>p = .076<br>d = -.19 | - | - |
| ***Clinical Variables*** | | | | | | |
| **SF-MPQ** | | | | | | |
| Present pain | 94 | 5.6 (2.2) | - | - | 7.3 (2.1)[8] | t = -7.20<br>p = .000<br>d = -.79 |

| Baseline Variable | N | ẋ (SD) | Norm.[ł] ẋ (SD) | Test and *p* value | Comp.[ł] ẋ (SD) | Test, *p* value and ES |
|---|---|---|---|---|---|---|
| Overall pain | 94 | 2.9 (1.0) | - | - | 2.6 (1.2)[8] | t = 3.01<br>p = .003<br>d = .27 |
| Sensory pain | 71 | 13.3 (6.9) | - | - | 10.4 (6.2)[8] | t = 3.64<br>p = .001<br>d = .44 |
| Affective pain | 71 | 4.2 (3.5) | - | - | 3.0 (2.6)[8] | t = 2.85<br>p = .006<br>d = .39 |
| Total pain | 71 | 17.6 (9.6) | - | - | 13.3 (7.8)[8] | t = 3.73<br>p = .000<br>d = .49 |
| RMDQ | 99 | 9.0 (5.1) | - | - | 11.1 (6.0)[9] | t = -3.9<br>p = .00<br>d = -.79 |

*Note: 'Norm' = normative data; 'comp' = comparison data from other CLBP samples. ES = effect size. [ł] Data are provided where they are available. [#] The Stroop test is divided into two groups for comparison with normative data. [1] Crawford et al. (2001); [2] Keeley et al. (2008); [3] Løchting et al. (2013). - Norwegian sample; [4] Quartana, Burns, and Lofland (2007) - USA sample; [7] Woods et al. (2011) - USA sample; [8] Mason et al. (2010); [9] Critchley et al. (2007).*

#### 6.4.3.1. Comparison of CLBP sample versus normative samples

**Psychosocial variables**

HADS depression, anxiety and overall distress were found to be significantly higher in the CLBP sample compared to normative data[1]. Effect sizes were small to moderate for the three variables (*d* = .44, .48, .52 respectively). According to Cohen's $U_3$ estimates, the mean of the CLBP sample was at approximately the 67$^{th}$, 68$^{th}$ and 70$^{th}$ percentiles of the normative sample respectively. Therefore, 67 to 70 percent of the CLBP sample scored above the mean of the normative sample for the HADS variables. There was an overlap of 80 to 83 percent of the scores for the two groups. Also, there was a 62 to 64 percent chance that a participant picked at random from the CLBP sample would have a higher score than a person picked at random from the normative sample (from here on referred to as 'probability of superiority'). These findings suggest that the present CLBP sample is more anxious, depressed and distressed than the normative sample. However, Cohen's $U_3$ estimates assume that the variable in question has a normal underlying distribution, which in the case of HADS depression scores is only approximately true. Therefore, caution should be displayed when interpreting Cohen's $U_3$ for variables such as HADS depression.

**Executive function variables**

There were no significant differences between the CLBP sample and normative data for premorbid IQ (WTAR) or working memory (BW digit span) and effect sizes were trivial (*d* < .2). However, mean scores for the CLBP sample were significantly lower than normative scores for behavioural inhibition (the Stroop test; 18-49 years and 50-65 years) and planning ability (the Zoo Map test). Effect sizes for the Stroop test were moderate (18-49 years: *d* = -.58) and large (50-65 years: *d* = -1.85). This indicates that approximately 73 percent of the CLBP sample aged 18-49 years (76% overlap; 66% probability of superiority) and 97 percent of those aged 50-65 years (35% overlap; 90% probability of superiority), scored below the mean of the normative sample for behavioural

inhibition. There was a small to moderate effect for the Zoo Map test (*d* = -.30), indicating that 62 percent of the CLBP sample scored below the mean of the normative sample for planning ability (88% overlap; 58% probability of superiority). Findings suggest that the CL BP sample are less able to inhibit certain behaviours (i.e. have difficulties selectively attending to specific stimuli) and have poorer planning ability when compared with normative samples. For most of the sample, differences in executive functions were small to moderate and these differences are of varying importance relative to the age of the sample in question. In the case of the present study, the CLBP sample are relatively young to be associated with executive function deficits due to age (ẋ=39 years), therefore it is expected that reasons other than increasing age (e.g. pain and disability) may partly explain this phenomenon. The CLBP sample did not display any meaningful issues regarding working memory or pre-morbid IQ.

#### 6.4.3.2. Comparison of CLBP sample vs other CLBP samples

**Psychosocial variables**

Mean scores for anxiety and depression in the present CLBP sample were significantly lower than a comparison CLBP sample[2]. Effect sizes were small (anxiety: d - .30) and moderate (depression: -.53). This indicates that 62 percent of the present sample scored below the mean of the comparison sample for anxiety (88% overlap; 58% probability of superiority). Furthermore, 69 percent scored below the mean for depression (80% overlap; 63% probability of superiority). The present CLBP sample had significantly higher mean scores for five out of the eight Brief IPQ items compared to a comparison CLBP sample (personal control, identity, concern, coherence and emotional representation). Effect sizes ranged from small to large (*d* = .32 - 1.05). This indicates that between 62 percent (88% overlap; 58% probability of superiority) and 84 percent (62% overlap; 76% probability of superiority) of the present sample scored above the mean of the comparison sample for these five items assessing illness perceptions. The present sample had significantly lower mean scores, with small effect sizes, for timeline (*d* = .25) and total Brief IPQ score (*d* = -.35). This indicates that 59 percent (timeline) to 63 percent (Brief IPQ total) of the present sample scored below the mean of the comparison sample for these

items. There was an overlap of 90 percent and 8 percent, and a probability of superiority of 57 percent and 60 percent respectively. There were no significant differences between scores for ‘consequences’ and ‘treatment control’, with effect sizes close to zero. Fear-avoidance beliefs in relation to work and exercise were significantly lower than a comparison CLBP sample[2]. Effect sizes were small (*d* = -.33 and *d* = -.47 respectively) indicating that between 61 and 69 percent of the present sample scored below the mean of the comparison sample. There was an overlap of 87 percent and 80 percent, and a probability of superiority of 59 percent and 63 percent respectively. There were no significant differences in pain catastrophizing between the present sample and a comparison CLBP sample[4] and the effect size was trivial (*d* = -.12) ($U_3$= 54%; 96% overlap; 53% probability of superiority).

**Clinical variables**

Means scores for the present CLBP sample were significantly higher than a comparison CLBP sample[8] for overall pain, sensory pain, affective pain and total pain (SF-MPQ). Effect sizes were small (i.e. *d* = .27 - .49) indicating that between 60 and 69 percent of the present sample scored above the mean of the comparison sample. Overlap between samples ranged from 88 percent down to 80 percent, and probability of superiority ranged from 63 percent down to 58 percent respectively. Mean scores for the present sample were significantly lower for present pain[8] (SF-MPQ) and disability[9] (RMDQ) and the effect sizes were moderate (*d* = -.79 for both variables) indicating that approximately 78 percent of the present sample scored below the mean of the comparison sample (68% overlap; 71% probability of superiority) for both clinical factors.

#### 6.4.3.3. Summary of baseline data comparisons

In comparison to normative data, the present CLBP sample presented with lower mood, poorer planning ability, higher behavioural inhibition, and similar working memory and pre-morbid IQ. These findings suggest that specific types of executive functions, rather than overall executive function processing, may be affected in the CLBP sample. Inferences relating to comparisons to other CLBP samples must be made with caution, as the comparison samples are not

necessarily matched in relation to important demographic and clinical variables. However, once this is taken into account, comparison samples do provide additional information about the present CLBP sample that would otherwise not be available. According to comparison data, the present CLBP sample presented with better mood and felt that their back pain would last for a shorter time. An inverse relationship between mood and timeline appears logical, and the present sample perceived their condition as less threatening than the comparison group overall. However, there was a large difference between the two samples in terms of concern about back pain, where the present sample were more likely to be extremely concerned about their condition. This may be partly due to the fact that the comparison sample included participants with sub-acute LBP (< 3 months) who are less likely to be concerned about their pain than those with longer-term CLBP. Pain catastrophizing symptoms were similar in both CLBP samples. However, there were moderate difference between CLBP samples in terms of present pain intensity and disability, where the present CLBP sample had lower levels of pain and disability on average than comparison samples. This contrasted with findings that other dimensions of pain were higher in the present sample (overall pain experience plus sensory and affective pain).

Main findings include moderate differences in pain and disability, where the present sample presented with lower disability (Critchley et al., 2007) and lower present pain intensity (Mason et al., 2010) than comparison samples. Mason and colleagues (2010) recruited their sample in the UK and Critchley and colleagues' (2007) recruited their sample from the same physiotherapy departments as the present study, providing useful comparisons. However, samples from Mason and colleagues (2010) and Critchley and colleagues (2007) vary from the present sample with respect to age ($\dot{x}$=58, 44 and 39 years respectively), where the present sample was considerably younger than the comparison samples. Furthermore, the present sample was 76 percent female, whereas the comparison samples were 68 and 60 percent female respectively. These comparisons suggest that findings from the present study may not be generalisable to the wider London and UK-based CLBP population.

### 6.4.4. Correlations between baseline variables

Pearson's r was used to assess the strength of associations between baseline IVs. A detailed table of correlations including demographic variables and sub-scale scores is displayed in Appendix 16. Table 15 shows correlations between total scores of the psychosocial, clinical and executive function variables.

**Table 15*. Correlations between baseline total scores of psychosocial, clinical and executive function variables***

| **Variable** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HADS distress | 1.000 | | | | | | | | | | |
| Brief IPQ total | .545** | 1.000 | | | | | | | | | |
| FABQ exercise | .230* | .309** | 1.000 | | | | | | | | |
| FABQ work | .450** | .428** | 0.189 | 1.000 | | | | | | | |
| PCS total | .646** | .614** | .328** | .420** | 1.000 | | | | | | |
| RMDQ disability | .540** | .624** | .270** | .424** | .626** | 1.000 | | | | | |
| SF-MPQ present pain | .338** | .518** | 0.137 | .232* | .418** | .581** | 1.000 | | | | |
| WTAR premorbid IQ | -0.167 | -0.203 | -0.182 | -.406** | -0.198 | -.299** | -0.189 | 1.000 | | | |
| Stroop test (18-65 yrs) | 0.091 | -.217* | -0.049 | -.262* | -0.092 | -.265* | -.297** | .370** | 1.000 | | |
| Zoo Map test | -0.118 | -0.187 | -.221* | -.241* | -0.166 | -.273** | -0.174 | .320** | .414** | 1.000 | |
| BW digit span | -0.032 | -0.155 | -0.200 | -.308** | -0.131 | -0.105 | -.225* | .506** | .354** | .311** | 1.000 |

*Note:* *p<.05. **p<.01

Table 15 shows strong relationships (r ≥ .5) found between: a) distress and disability, illness perceptions and pain catastrophizing; b) illness perceptions and pain catastrophizing, present pain intensity plus disability; c) disability and pain catastrophizing; and d) working memory and pre-morbid IQ. Moderate relationships (r ≥ .3) were found between: a) illness perceptions and fear-avoidance beliefs (exercise and work), b) pain catastrophizing and fear-avoidance beliefs (exercise and work), c) disability and fear-avoidance beliefs (work), d) present pain intensity and pain catastrophizing, e) pre-morbid IQ and fear-avoidance beliefs (work), f) behavioural inhibition and both planning ability and working memory, and g) planning ability and both pre-morbid IQ and behavioural inhibition.

In summary, the four executive function variables all displayed small relationships with pain and disability (r ≥ .1). In all but two cases where relationships were moderate (i.e. pre-morbid IQ and working memory with fear-avoidance beliefs in relation to work), relationships between executive function and psychosocial variables were either trivial (r < .1) or small (r ≥ .1). Large relationships (r ≥ .5) were found between disability and three out of the four psychosocial variables (distress, illness perceptions and pain catastrophizing). Relationships between present pain intensity and psychosocial variables were weaker in general, with a large relationship being shown for only one psychosocial variable (pain catastrophizing). This suggests that disability is more strongly influenced by psychosocial influences than pain in the current? CLBP sample.

## 6.5. Discussion

This discussion of baseline findings consists of four sections. Firstly, findings regarding characteristics of the present CLBP sample are discussed (6.5.1.). Baseline findings regarding executive functions are then discussed in relation to existing CLBP and chronic pain research literature (6.5.2). Methodological considerations, research and clinical implications of Study 3 are discussed with regards to findings from baseline and follow-up data analyses in the next chapter (Chapter 7).

### 6.5.1. Characteristics of the present CLBP sample

The present CLBP sample displayed less severity of clinical symptoms compared to other CLBP samples. This suggests that the findings of Study 3 may not be easily generalisable to the wider London and UK-based CLBP population. Main findings include moderate differences in pain and disability, where the present sample presented with lower disability (Critchley et al., 2007) and lower present pain intensity (Mason et al., 2010) than comparison samples. Mason and colleagues (2010) recruited their sample in the UK and Critchley and colleagues' (2007) recruited their sample from the same London-based physiotherapy departments as the present study, providing useful comparisons.

Mason and colleagues' (2010) and Critchley and colleagues' (2007) CLBP samples vary from the present sample with respect to age ($\dot{x}$=58, 44 and 39 years respectively), where the present sample was considerably younger than the comparison samples. Age was significantly and positively correlated with pain (r=.217, p=.03) and disability (r=.318, p=.001) in the present sample. These correlations suggest that an older sample from the same population is likely to display higher pain and disability. This is in line with findings from the two comparison studies. In addition to this, the present sample was 76 percent female, whereas the comparison samples were 68 percent (Mason et al., 2010) and 60 percent (Critchley et al., 2007) female.

Reasons for differences in age and gender may relate to the age (36 years) and gender (female) of the researcher recruiting data. Recruiter characteristics have been shown to influence characteristics of recruited participants (Newington & Metcalfe, 2014). For example, cognitive dissonance theory states that people

try to create consistency in their daily life by being accepting of situations that are similar to beliefs about their 'self' (Festinger, 1962). The theory states that dissimilarity creates inconsistency and subsequent avoidance of such situations. Therefore, it may be likely that mutually agreeable communication led to a final sample that was younger and more female than expected based on previous research.

Cognitive dissonance theory provides a potential reason for differences in age and gender between the present CLBP sample and the two comparison samples. However, there is an additional reason that relates to differences between the present sample and the sample recruited at the same physiotherapy departments (i.e. Critchley et al., 2007). Critchley and colleagues (2007) had access to all patients referred to GSTT with CLBP. However, since then the referral process changed so that some patients with higher clinical symptoms were referred directly to the orthopaedic department for further assessment. These changes occurred during recruitment in the present study, and meant that these patients were not available to recruit. Therefore, it is unsurprising that the present CLBP sample had lower disability and pain levels than comparison samples.

Results of comparisons between the present CLBP sample and other samples indicate that findings from Study 3 may be under-representative of individuals in the UK with CLBP. This may be due to the fact that executive functions diminish with age and women are less likely to exercise than men. Therefore, it is possible that the present CLBP sample may be less likely to display executive function deficits and more likely to display non-adherence, therefore weakening the results of observed relationships. Comparison with the CLBP sample recruited for the development of the Exercise Adherence Rating Scale (EARS) (Chapter 4) provides further evidence that the sample recruited for the present study is particularly young and includes more women than the CLBP population in general (EARS sample = 60% female and $\dot{x}$=49 years). However, disability and pain were almost identical in both samples ($\dot{x}$ disability for present sample = 9.0; $\dot{x}$ for EARS sample = 9.5; $\dot{x}$ present pain intensity for both samples = 5.6) indicating that age and gender may be main reasons for problems of generalisation with the present study.

### 6.5.2. Findings in relation to existing research

The present research posited that individuals with CLBP might have executive function deficits due to past evidence of neurological change and executive function deficits individuals with CLBP (e.g. Wand et al., 2011). Study 3 partly supported previous evidence with baseline findings that the CLBP sample displayed higher behavioural inhibition (i.e. difficulties selectively attending to specific stimuli) and poorer planning ability when compared to normative samples. However, there were no meaningful issues regarding working memory or pre-morbid IQ. These findings are discussed here in relation to existing research.

This section discusses empirical studies investigating executive functions in CLBP, with a focus on executive function abilities assessed in the present research. Research evidence is presented in two sections: executive function deficits found in the present study (i.e. behavioural inhibition and planning ability) (6.5.2.1.) and executive function deficits not found in the present study (i.e. working memory and pre-morbid IQ) (6.5.2.2.). Evidence of findings from mixed chronic pain samples is discussed where CLBP research is particularly limited, as this can provide some insights where CLBP research is unavailable. In both sections, one executive function has been investigated more frequently in chronic pain and CLBP than the other. Therefore, discussion focuses mainly on available chronic pain and CLBP research literature.

#### 6.5.2.1. Deficits found in Study 3: (i.e. planning and behavioural inhibition)

Planning requires the ability to organise behaviour according to a sequence of steps in order to carry out a course of action (Owen, 1997; Luria, 1978). In the present study, it was posited that adherence to exercise requires deliberate planning prior to the initiation of the exercise behaviour itself (McAuley et al., 2011; Hagger et al., 2010). To the author's knowledge, the present study was the first to assess planning ability in a CLBP sample. Indeed, planning ability was only recently assessed in a mixed chronic pain sample using the same measure as the present study (i.e. the Zoo Map test) where no planning deficits were found (Oosterman et al., 2012). Decision making has recently been investigated in a CLBP sample (Tamburin et al., 2014) using the Iowa Gambling

Task (IGT) (Bechara, Damasio, Damasio, & Anderson, 1994). CLBP participants displayed lower scores than controls on the IGT, providing evidence of poor decision-making. The IGT has been argued to assess planning ability as well as decision-making (e.g. Bechara & Martin, 2004; Maia & McClelland, 2004). Therefore, these findings can be argued to provide useful additional information in an under-research area.

Due to the paucity of research investigating planning ability in chronic pain conditions, the main focus of this section is on behavioural inhibition. However, evidence of behavioural inhibition is relevant to problems of planning ability in real life situations involving interference (e.g. following exercise advice for a chronic pain condition) (Root-Bernstein, 2007). This seems logical in the light of the findings of the present study where deficits in both behavioural inhibition and planning ability were found. Therefore, it is suggested that behavioural inhibition research is considered with the knowledge that deficits in behavioural inhibition may be associated with deficits in planning ability.

Behavioural inhibition refers to a tendency to focus on certain stimuli (e.g. pain), whilst ignoring other potentially important stimuli (e.g. following exercise instructions). Behavioural inhibition due to a threat such as pain, is argued to influence the ability to delay habitual responses such as watching a television program, in order to focus on effortful behaviour such as exercise (Pérez-Edgar et al., 2010). Therefore, research assessing behavioural inhibition relates directly to problems of behavioural inhibition. Research assessing behavioural inhibition in mixed chronic pain samples has been inconsistent. For example, Pearce and Morley (1989) found that a mixed chronic pain sample displayed behavioural inhibition to sensory and affective pain-related words. However, replications of these results have been largely unsuccessful (Pincus & Morley, 2000). Furthermore, as previously stated, results from mixed chronic pain samples cannot easily be generalised to CLBP. Therefore, results from the limited number of studies that have assessed behavioural inhibition in CLBP are presented in evaluation of the present research.

Findings support the results of the present study that problems of behavioural inhibition exist in individuals CLBP (e.g. Sharpe, Haggman, Nicholas, Dear, &

Refshauge, 2014; Haggman, Sharpe, Nicholas, & Refshauge, 2010; Crombez et al., 2000). However, behavioural inhibition was assessed using different types of tasks across these studies, and no one study used an unmodified Stroop task like the present study. Sharpe and colleagues (2014) and Haggman and colleagues (2010) found behavioural inhibition towards sensory, but not affective, pain-related words in a CLBP sample using a dot-probe task. Crombez and colleagues (2000) reported identical results using a modified emotional Stroop task.

Although two different tasks were used to assess behavioural inhibition across these studies, they all used similar neutral, sensory and affective stimuli. Furthermore, the two studies using the dot-probe task used identical stimuli (i.e. Sharpe et al., 2014; Haggman et al., 2010). Together with the results of the present study, it could be argued that individuals with CLBP display a variety of behavioural inhibitions that may affect new or difficult daily tasks that require specific attentional focus (e.g. exercise). However, lack of psychometric data for both the modified emotional Stroop task (Roelofs, 2005) and the dot-probe task (Price et al., 2015; Dear et al., 2011) leads to questions regarding the reliability of results of studies using these measures. Furthermore, it has recently been asserted that assessment of behavioural inhibition using pain-related stimuli does not actually assess deficits of executive function, but rather examines the effects of pain-related stimuli on attentional capture (Berryman et al., 2013; Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013). More studies assessing behavioural inhibition using an unmodified Stroop task, as in the present study, would provide information about general behavioural inhibition deficits in CLBP. This, in turn, may allow for inferences about behavioural inhibition deficits in CLBP and how these may be related to the treatment of CLBP. Issues relating to the use of the Stroop task are discussed in relation to limitations of the present research in the next chapter (Chapter 7).

#### 6.5.2.2. No deficits found in Study 3: (i.e. pre-morbid IQ and working memory)

Pre-morbid IQ is an estimate of intelligence prior to a neurological dysfunction. Assessment of pre-morbid intelligence is an essential part of

neuropsychological evaluation (Lanham & Misukanis, 1999), however has largely not been assessed in chronic pain research assessing executive functions. Pre-morbid IQ assesses crystallized (rather than fluid) intelligence, which is influenced by educational experience (de Oliveira, Nitrini, Yassuda, & Brucki, 2014). Therefore, in some studies information regarding level of education could provide useful comparison data where pre-morbid IQ has not been studied. Additional information, together with level of education (e.g. work-related attainment and level of engagement in cognitive activities), could be combined to provide a comparable assessment of pre-morbid IQ (Vemuri et al., 2011). However, these factors were not assessed in the present research. Therefore, the remainder of this section focuses on findings relating to working memory, where similar to findings relating to pre-morbid IQ, no meaningful issues were found in the present CLBP sample.

Working memory refers to the temporary storing and manipulating of information necessary for complex cognitive tasks (e.g. preparation for the later use of exercise instructions) (Baddeley, 1992). Research investigating working memory in CLBP has been conflicting. Shuchang and colleagues (2011) assessed working memory in CLBP and found no differences between a CLBP sample and a control group, although they found deficits in reaction time in the CLBP sample. Three further studies that assessed working memory in CLBP were found, and all three revealed evidence of working memory deficits in CLBP (Wesnes & Annas, 2012; Jorge et al., 2009; Dick & Rashiq, 2007). These differences in findings may be due to a variety of reasons including differences in the quality of research and differences in participant characteristics. For example, Shuchang and colleagues (2011) CLBP sample had a lower mean duration of pain (ẋ=3.6 years) than both Jorge and colleagues (2009) (ẋ=5.5 years) and the present study (ẋ=6.2 years). This may explain Shuchang and colleagues' (2011) negative findings, as executive functions decline with increasing age, therefore a younger sample are less likely to show evidence of deficit (Hull et al., 2008). Furthermore, different measures were used across studies to assess working memory. For example, the Wechsler Memory Scale III (WMS III, Wechsler, 1997 in Jorge et al., 2009), the WHO Neuro-behavioural Core Test battery (Letz, cited in Shuchang et al., 2011), the CDR computerized

assessment system (Keith et al., 1998 in Wesnes & Annas, 2012) and the spatial span test (Shah et al., 1996 in Dick & Rashiq, 2007).

The present study assessed working memory using the BW digit span test from the WMS III. Therefore, findings from Jorge and colleagues' (2009) study may be considered the most comparable to the present research. In addition to this, the WHO Neuro-behavioural Core Test battery uses a digit span test to assess working memory. Therefore, Shuchang and colleagues' (2011) findings may also be considered comparable to the present research. However, closer examination of both studies found that a total score for the forwards (FW) and BW digit span test was used to assess working memory. The FW and BW digit span are considered to assess different cognitive constructs (Choi et al., 2014). This suggests that none of the four studies assessing working memory in CLBP can provide an accurate comparison for the findings of the present research. Evidently, findings regarding working memory deficits in CLBP remain unclear at the current time.

### 6.6. Summary of baseline findings for Study 3

This chapter discussed methods and results of analyses for Research Objective 3. Research Objective 3 involved assessment and examination of relationships between psychosocial, clinical and executive function factors in CLBP. The present CLBP sample was compared to other CLBP samples and normative data for each baseline variable. The present CLBP sample demonstrated moderately lower scores for anxiety and depression compared to normative data. In addition to this, differences between the present CLBP sample and comparison samples for fear-avoidance beliefs and illness perceptions were small to moderate. Both level of pain and pain catastrophizing were similar across CLBP samples. Moderate differences were found in pain and disability, where the present sample presented with lower disability (Critchley et al., 2007) and lower present pain intensity (Mason et al., 2010) when compared to other UK-based CLBP samples. These differences suggest that findings from the present study may be under-representative of individuals in the UK with CLBP.

Individuals with CLBP demonstrated lower than normative scores on executive function tasks assessing planning ability and behavioural inhibition. However,

scores were within normative ranges for tasks assessing working memory and pre-morbid IQ. These findings add to the growing body of CLBP research literature that has found neurological changes and executive function deficits in CLBP samples (e.g. Wand et al., 2011). Poor performance on executive function tasks has been associated with difficulties performing activities of daily living necessary for successful exercise behaviour (e.g. planning, problem-solving and behavioural inhibition) (e.g. McAuley et al., 2011). Therefore, the next chapter discusses investigation of executive functions, together with psychosocial and clinical factors, in relation to exercise adherence behaviour in CLBP (Chapter 7).

# 7. Study 3: Follow-up Methods of Analyses and Results

## 7.1. Overview

This chapter discusses the follow-up methods of analysis and results for Study 3. This chapter consists of five sections. First, there is a brief summary of methods and procedure conducted to collect follow-up data (7.2.). Then, methods of analysis for follow-up data are described (7.3.). Subsequent to this, discussion focuses on the results of follow-up data analyses (7.4.). Next, there is a discussion of follow-up data findings in relation to extant CLBP and musculoskeletal (MSK) research literature (7.5.). The discussion focuses on methodological considerations and clinical and research implications of Study 3. Last, conclusions regarding baseline and follow-up findings from Study 3 are summarised (7.6.).

## 7.2. Follow-up data collection methods and procedure

Research Objectives 4 and 5 refer to follow-up data collection and analysis for Study 3 (7.2.1.). Follow-up methods and procedure are discussed in detail in the research protocol for Study 3 (Chapter 5). However, methods and procedures are briefly summarised here for purposes of clarity with consideration of how the planned design was adapted in light of challenges encountered (7.2.2.). Next, discussion focuses on participant recruitment and flow throughout Study 3 (7.2.3.).

### 7.2.1. Research Objectives and Hypothesis

**Research Objective 4:**

To evaluate the possible roles of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in CLBP.

Psychosocial factors (e.g. distress) and clinical factors (i.e. pain and disability) have been associated with adherence to prescribed home exercise in CLBP (Beinart et al., 2013). Executive functions have been found to predict exercise behaviour in a healthy sample (Hall et al., 2008). The influence of executive functions is posited to be particularly relevant to exercise behaviour in a CLBP sample because executive function deficits have been found in individuals with

CLBP (Wand et al., 2011). Therefore, the fourth research objective investigates the predictive value of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in a CLBP sample. This is tested by construction of multiple regression models with predictors based on theoretical and statistical rationales.

**Research Objective 5:**

To determine whether adherence to prescribed home exercise is related to clinical outcome.

Relationships between clinical outcome and exercise adherence behaviour have rarely been assessed. The few studies that have investigated these relationships found no relationships between changes in clinical outcome and adherence (Mailloux et al., 2006) and inverse relationships between disability (Harkapaa et al., 1991), pain (Donzelli et al., 2006) and subsequent adherence behaviour. Exercise is a main treatment prescribed to treat CLBP (NICE, 2009). Lack of research in this area indicates that further investigations are necessary to improve understanding of relationships between clinical factors that characterise CLBP as a chronic condition (i.e. pain and disability) and exercise adherence behaviour. Thus, the fifth research objective assesses relationships between adherence to prescribed home exercise and self-reported disability and pain. Correlational analysis investigates relationships between baseline clinical factors and changes in clinical factors over time and subsequent adherence behaviour.

**Hypothesis:** Executive functions will predict additional variance in adherence behaviour over and above that which is explained by psychosocial and clinical factors.

Much of the research investigating relationships between executive functions and health exercise behaviours has focused on the positive effects of exercise on executive function processes in healthy samples (Buckley et al., 2014). Less research has investigated the influence of executive functions on exercise behaviour (Hall et al., 2008a). However, preliminary evidence has found that executive functions are predictive of exercise behaviour in healthy samples

(McAuley et al., 2011; Riggs et al., 2010; Hall et al., 2008). Therefore, in Study 3, executive functions are posited to predict additional variance in adherence behaviour over and above that which is explained by psychosocial and clinical factors.

### 7.2.2. Summary of follow-up methods for Study 3

This was a prospective, observational study with follow-up at 3 months. Follow-up at 3 months was done over the telephone and consisted of reassessment of pain (the Short Form McGill, SF-MPQ) and disability (the Roland Morris Disability Questionnaire, RMDQ) and the Exercise Adherence Rating Scale (EARS) to assess exercise adherence behaviour as the main outcome. Prior to completing the EARS, the Prescribed Exercise Questionnaire (PEQ) asks what exercises have been prescribed as part of treatment and how often these exercises have been recommended to be carried out. A further question asks how often exercises are being done at the present time. Qualitative adherence data were provided by an open-ended question asked to participants prior to completing the EARS questionnaire. This item was “in your own words, please can you explain why you have, or have not, done your exercises?” Additional assessment of adherence behaviour was provided by physiotherapists using the Sports Injury Rehabilitation Scale (SIRAS, Kolt et al., 2007).

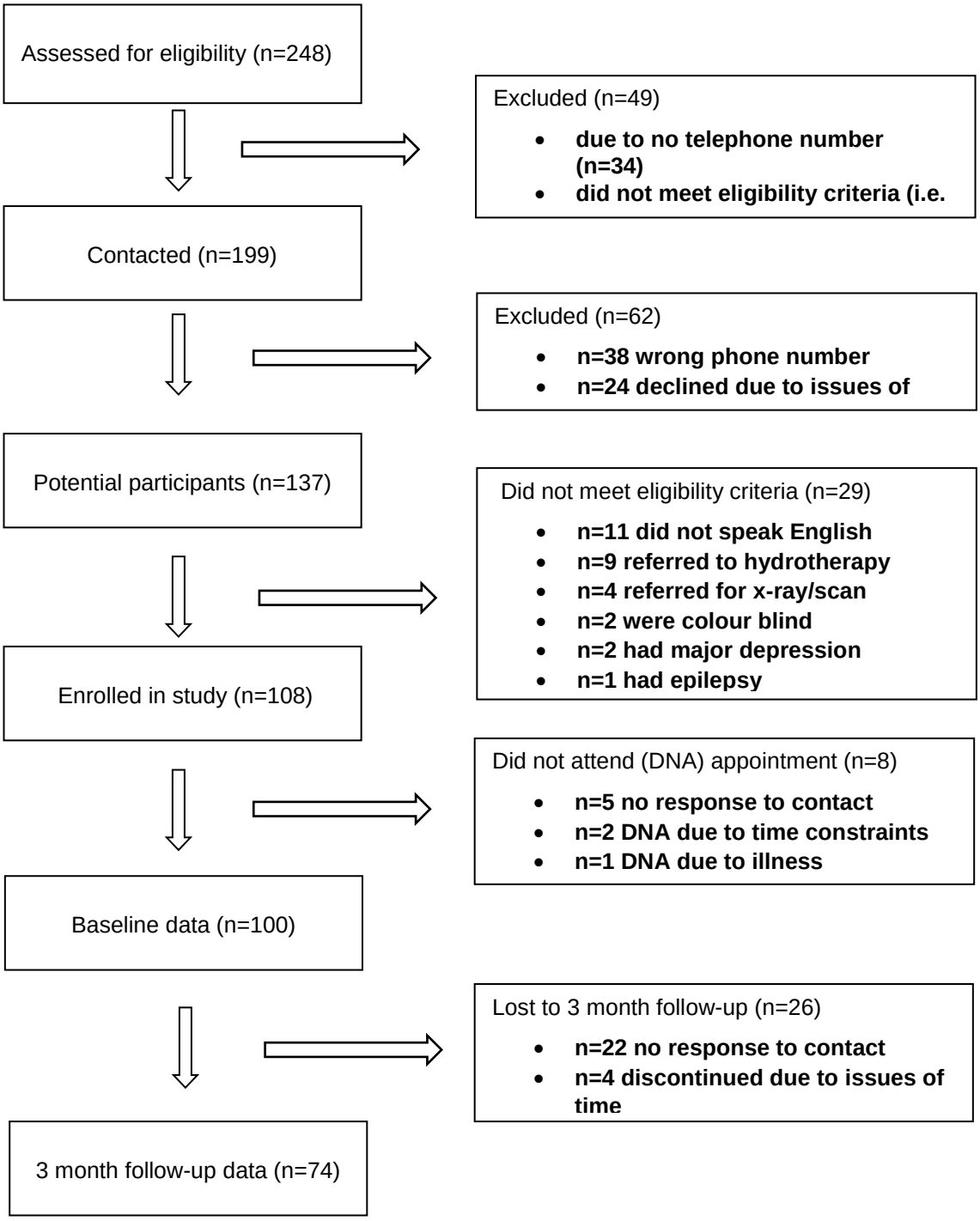
### 7.2.3. Participant recruitment and flow throughout Study 3

According to the sample size calculations, 159 participants were needed at baseline allowing for a 20 percent attrition rate (Tabachnick & Fidell, 2007). However, a final number of 100 participants were recruited at baseline. Chapter 6 provides a detailed description of participant flow from the initial stages of recruitment until the end of baseline data collection (Section 6.2.6.2.). However, Figure 8 displays participant progress for the duration of Study 3 for purposes of clarity. Twenty-six (26%) of participants recruited at baseline did not complete 3 month follow-up measures, resulting in 74 participants for analyses. Attrition was six percent higher than the 20 percent anticipated based on (Tabachnick & Fidell, 2007) recommendations. Contacting participants with reminders about 3 month follow-up data collection was considered, however this may have affected adherence behaviour due to reminding participants that the study assessed adherence to prescribed home exercise. Additional contact may also

have been perceived as a type of supervision or support, and had a motivational effect on the participant, therefore also affecting adherence behaviour (Liddle et al., 2004). Therefore, no measures were taken to address attrition.

The smaller than expected final sample meant a reduction in statistical power, and the 26 percent attrition rate at 3 month follow-up reduced statistical power further. This meant that the detectable effect size (ES) would also be reduced, increasing the risk of failing to reject a false null hypothesis (a Type 2 error). It was important to consider how analysis may be modified to best account for the smaller than expected sample size. This is further discussed later in this chapter together with assumptions of regression analysis in relation to sample size (Section 7.3.2.1).

**Figure 8.** ***Flow diagram of participant progress throughout Study 3***



## 7.3. Methods for follow-up data analyses

This section describes methods used to analyse follow-up data for Study 3. Firstly, methods used to analyse missing data are discussed (7.3.1). Secondly, discussion focuses on methods of analyses used to investigate Research Objective 4 (7.3.2.). The next section describes methods of analysis used to investigate Research Objective 5 (7.3.3.). Lastly, methods are described that were used to further analyse exercise adherence data, including post-hoc analysis of qualitative data (7.3.4.).

### 7.3.1. Methods of missing data analysis

Missing data were evaluated for individual observed measures (i.e. within questionnaires) using missing value analysis (MVA) and across baseline observed measures (i.e. cross-sectionally between questionnaires) (7.3.1.1.). Missing data were also evaluated for attrition at 3 month follow-up (i.e. longitudinally) (7.3.1.2.).

#### 7.3.1.1. Missing data within and between questionnaires

There is no definitive test of missing data, however certain analyses can provide information to ensure that assumptions about type of missing data are not clearly violated. MVA was performed to assess missing data within questionnaires and cross-sectionally between questionnaires. MVA provided information about the amount of missing data, where the missing data were located and whether or not data could be considered missing completely at random (MCAR). Where missing data were more than five percent for a single observed variable, separate variance t-tests were calculated to investigate the likelihood of this data to be MCAR. The further the t-value from ± 2, the greater the departure from randomness and the less likely the data were to be MCAR. Little's MCAR test was calculated as a further evaluation of the MCAR assumption. The null hypothesis for this test is that missing data are MCAR. Therefore, a non-significant *p* value (i.e. $p \geq .5$) constitutes a failure to reject the null hypothesis and an indication that the data could potentially be MCAR. However, a non-significant *p* value does not imply sufficient evidence to support the null hypothesis and Little's MCAR test is not sufficient to confirm the data MCAR.

Once it was decided which missing data mechanism was most likely to fit the data (i.e. MCAR, MAR or MNAR), subsequent analyses accounted for this. This is because violation of any of these assumptions can lead to biased parameter estimates (B) and standard errors (SE), thus invalidating results to some extent. If data were decided likely to be MCAR, listwise deletion was considered an acceptable approach for further analyse. However, researchers can rarely be certain that data are MCAR. Therefore, a sensitivity analysis was proposed to aid investigation of the likely missingness mechanism by exploring how results varied under MCAR (i.e. listwise deletion) and MAR (i.e. multiple imputation, MI) assumptions. Techniques regarding missing data handling are described in Chapter 2.

#### 7.3.1.2. Missing data due to attrition

Completers and non-completers of 3 month follow-up measures were compared using the Independent t-test or $Chi^2$ test to observe differences between the two groups of participants in relation to observed baseline measures. Means, standard deviations, *p* values, Cohen's *d* and Cohen's $U_3$ were calculated. Differences in observed characteristics between Group 1 and Group 2 would indicate that data were likely not missing completely at random (MCAR), and subsequent analysis would take this into consideration using some evaluation of a MAR analysis.

### 7.3.2. Methods of analyses for Research Objective 4

Main assumptions of multiple regression were tested prior to analyses (Field, 2009; Tabachnick & Fidell, 2007). Findings regarding sample size, multicollinearity, outliers, normality, linearity and homoscedasticity of residuals are discussed (7.3.2.1.). A plan of analysis is described for two hierarchical multiple regression models (Regressions 1 and 2) and six standard multiple regression models (Regressions 3 to 8) to explore the predictive value of the independent variables on adherence behaviour (the EARS) (7.3.2.2.). Discussion then focuses on a sensitivity analysis that was carried out to explore how the results of Regression 1 varied under MCAR and MAR assumptions, using listwise deletion and MI respectively (7.3.2.3.).

#### 7.3.2.1. Main assumptions of regression analysis

Sample size was calculated as described in the protocol for Study 3 (Chapter 5). Issues resulting from the smaller than expected final sample size are discussed first (7.3.2.1.1.). Multicollinearity is discussed next (7.3.2.1.2.). Normality, linearity, homoscedasticity of residuals were the final assumptions assessed prior to regression analyses (7.3.2.1.3.).

##### 7.3.2.1.1. Sample size

The smaller than expected final sample (n=74) meant a reduction in statistical power. A sample size of n=127 was required in order to detect small to medium effects. A lesser sample size meant that this assumption of regression analysis was not met. This led to a decrease in power and a reduction in the detectable ES, therefore, a statistically significant effect may be difficult to detect, even if one exists. However, measures to reduce variables included in the hierarchical regression models (Regressions 1 and 2) were not taken. The decision was made to continue with the original plan of analysis with the understanding that the diminished sample size may reduce the precision of parameter estimates and predicted values.

##### 7.3.2.1.2. Absence of multicollinearity

Pearson's correlations were used to assess multicollinearity (Appendix 16). High correlations were expected between total-score variables and related sub-scales, as by nature these should assess aspects of the same overall construct. However, in these circumstances, the variable with the largest relationship with adherence would be selected for subsequent analyses. No independent variables assessing different constructs were found to be extremely highly correlated (i.e. $r \geq .9$). Furthermore, the VIF statistic for all independent variables was within acceptable limits ($VIF < 10$) therefore the assumption of multicollinearity was deemed to have been met. However, as expected, two total-score variables were correlated above .9 with their related sub-scale scores. These variables were HADS distress (HADS anxiety, r=.924 and HADS depression, r=.902) and PCS total (PCS helplessness, r=.958; PCS magnification, r=.902; and PCS rumination, r=.941).

#### 7.3.2.1.3. Absence of outliers

Variables selected for entry into the regression models were screened for univariate outliers. Univariate outliers were found for two variables: i) general health (participant ID 14, 31 and 76) and ii) duration of pain (participant ID 31 and 36). There were no extreme univariate outliers. The 5 percent trimmed mean was examined for both variables and was found to be similar to the arithmetic mean (general health $\dot{x} = 2.73$ vs. 5% $\dot{x} = 2.72$; duration of pain $\dot{x} = 6.2$ vs. 5% $\dot{x} = 5.6$). Therefore, it seemed that the outliers did not have a large influence on the mean scores for the two variables. Furthermore, the outliers were scores that were a legitimate part of the sample. Removing the outliers prior to analysis would cause subsequent results to not accurately reflect the original sample. However, to confirm further the effects of outliers on the data, Mahalanobis distance was inspected for each variable to assess multivariate outliers. The criterion for Mahalanobis distance was calculated by estimating the Chi² ($\chi^2$) statistic where the degrees of freedom (df) were equal to the number of independent variables (e.g. 11 for Regression 1). In this case, $\chi^2$ at $p < .001$ for 11 df = 34.528 and $\chi^2$ at $p < .001$ for 14 df = 34.528. Therefore, any variable with a Mahalanobis distance greater than 34.528 was recognised as a multivariate outlier. Mahalanobis distance's ranged from 3.497 to 26.653. This was repeated for Regression 2 where no multivariate outliers were found. Therefore no outliers were removed from the dataset.

#### 7.3.2.1.4. Normality, linearity, homoscedasticity of residuals

Normality, linearity, homoscedasticity of residuals were the final assumptions assessed prior to regression analyses. Normality was assessed as described in the previous chapter (Chapter 6, Section 6.3.1.). All variables entered into the regressions were normally distributed. Homoscedasticity of residuals was assessed by the Levene statistic. Variables with a non-significant result ($p > .05$) met this assumption. For variables that violated the assumption of homoscedasticity, residual scatterplots were produced to assess the issue further.

### 7.3.2.2. Plan of regression analyses

Two hierarchical multiple regression models (Regressions 1 and 2) and six standard multiple regression models (Regressions 3 to 8) were constructed to

explore the predictive value of the independent variables on adherence behaviour. Hierarchical multiple regression was selected over standard multiple regression for the first two models as it allowed independent variables to be assessed based on variance they could add to the model after controlling for previously entered variables (Pallant, 2007). Listwise deletion was chosen for the main hierarchical regression model (Regression 1). The analysis was repeated using MI incorporating variables that differed between completers and non-completers at baseline. This analysis was compared to the results of the previous regression model as a sensitivity analysis to investigate how the results of Regression 1 varied under MCAR and MAR assumptions.

Order of entry of independent variables for each step of the two regression models was based on theoretical and statistical rationales, as recommended by Cohen, Cohen, West, and Aiken (1983). The theoretical rationale was based on the hypothesis that executive functions predict additional adherence behaviour over and above variance in adherence behaviour that is explained by clinical and psychosocial variables. Hence, executive functions were entered in the last stage of each regression analysis. Within each stage potential variables were selected for entry into the regression models based on correlations (i.e. the strength of their relationship with adherence) rather than statistical significance. This has an advantage over the use of statistical significance as it provides a method of quantifying differences between two groups. Variables with an ES of $r \geq .2$ were considered for entry into the regression models. For variables with an intercorrelation of $r \geq .7$ that measured similar constructs, the variable with the larger relationship with adherence was selected for entry into the model (Tabachnick & Fidell, 2007).

#### 7.3.2.3. Sensitivity analysis

A sensitivity analysis was carried out to explore how the results of Regression 1 varied under MCAR and MAR assumptions, using listwise deletion and MI respectively. Regression 1 was repeated using 5 multiply imputed datasets and a chained equations approach to probe whether the assumption of MCAR for the small number with missing baseline data impacted substantially on the estimates. Multiple imputation (MI) using chained equations (MICE) is described in Chapter 2. All variables that might be used in subsequent analyses, as well

as variables that may be predictive of missing data, were included for MI (Azur et al., 2011). Variables were included whether or not they contained missing data values.

Analysis was then run for the original dataset plus the five MI datasets. Arithmetic means for standardised beta coefficients (β) were calculated to provide approximate pooled estimates for multiply imputed data. This is because SPSS does not provide pooled data for statistics that are not computed using standard errors. If the MCAR assumption is not met, listwise deletion will produce biased parameter estimates when compared to the regression using the MI dataset. This would indicate that MICE, rather than listwise deletion of data, would be the most suitable technique for handling missing data assuming that no other investigations of missingness (i.e. analysis of attrition data and MVA) suggest that data may be MNAR, rather than MAR.

### 7.3.3. Methods of analyses for Research Objective 5

The fifth research objective investigated whether adherence to prescribed home exercise is related to clinical outcome. There were two parts to this objective. First, changes in pain and disability between baseline and 3 month follow-up were examined (7.3.3.1.). Changes in disability scores were examined in relation to clinically significant change. Second, relationships between clinical factors and adherence behaviour were examined. (7.3.3.2.). Issues of pain and disability being related to attrition, as well as adherence behaviour, are considered in relation to results of these analyses later in this chapter.

#### 7.3.3.1. Change in clinical factors over time

Change scores were calculated for pain and disability by subtracting baseline scores from scores at 3 month follow-up. The resulting score was positive if there was an increase in pain or disability (i.e. symptoms worsened) and negative if there was a decrease in pain or disability (i.e. symptoms improved) at 3 months. Percentages of the sample were calculated to display increases and decreases in clinical scores for each 1 point change in score. Changes in disability are considered in relation to clinically significant change, where a change score of between 2 and 3 points depicts clinically significant change (Patrick et al., 1995). There are no agreed clinically significant change scores

for present pain intensity, therefore discussion specific to clinically significant change does not include present pain intensity scores.

#### 7.3.3.2. Clinical factors and adherence behaviour

Pearson's correlations were conducted to determine relationships between clinical factors and adherence behaviour at 3 months (the EARS). First, baseline clinical factors were correlated with adherence behaviour. Then, change scores for pain and disability were correlated with adherence behaviour. Independent t-tests were calculated to assess differences in adherence behaviour for individuals with clinically significant changes in disability and the rest of the sample. This is discussed in relation to clinical significant change.

### 7.3.4. Methods for further analysis of exercise adherence data

In order to triangulate adherence data, two further assessments of adherence behaviour were obtained in addition to 6-item EARS. Methods of analysis for data resulting from the three measures is described (7.3.4.1.). Data regarding explanations for adherence behaviour provided a further understanding of exercise adherence behaviour in the present CLBP sample. Analysis of these data was planned after the initial plan of analysis for Study 3, and therefore, is defined as post-hoc analysis. Data were analysed using correlational analysis together with a content analysis of qualitative data (7.3.4.2.).

#### 7.3.4.1. Triangulation of adherence behaviour data

Self-report exercise adherence data were collected regarding number of days per week a participant was asked to exercise compared to the number of days per week they were actually exercising. In addition to this, physiotherapists were asked to provide data on the exercise adherence behaviour of their patients using the SIRAS. Descriptive statistics were used to compare and describe data for the three measures of adherence behaviour. Similarities between measures was believed to provide initial evidence that all three measurements of adherence behaviour may assess the same construct (i.e. adherence behaviour).

#### 7.3.4.2. Explanations for adherence behaviour

Subsequent to completing the EARS, participants completed 10 ‘reasons’ items relating to what helps or hinders doing their exercises (Appendix 4c). Mean scores for the 10 ‘reasons’ items were correlated with baseline total-scores of psychosocial, clinical and executive functions variables. The correlations provide information regarding relationships between each ‘reasons’ item and variables that that may help to explain the reasons for adherent and non-adherent behaviours.

Participants also completed an open-ended question asking ‘in your own words, please can you explain why you have, or have not, done your exercises?’ A post-hoc content analysis was conducted of data provided in response to the open-ended question. Five stages of conventional content analysis were followed as described by Hsieh and Shannon (2005): a) familiarisation with the data, b) generation of preliminary codes from the data, c) examining codes and combining or sub-categorising them where appropriate, d) reviewing codes and e) finalising codes.

### 7.4. Follow-up data analysis

This section describes the results of follow-up data analysis for Study 3. Firstly, missing data analyses provides evidence of type of missing data in the study (7.4.1.). This information informs how to handle missing data in subsequent analyses. Results of analyses based on Research Objective 4 are then provided (7.4.2.). Two hierarchical regression models, a sensitivity analysis and 6 multiple regression models are discussed. Discussion then focuses on the results of analyses based on Research Objective 5 (7.4.3.). Descriptive statistics and correlational analysis provide information regarding relationships between clinical factors (i.e. pain and disability) and adherence behaviour at 3 months. Further analyses of exercise adherence data are then discussed (7.4.4.). Triangulated adherence data is described and a post-hoc content analysis of explanations of adherence behaviour is presented.

### 7.4.1. Results of missing data analyses

Missing data were assessed across baseline observed measures (i.e. between questionnaires) and for individual observed measures (i.e. within questionnaires) using missing value analysis (MVA) (7.4.1.1.). Analysis of attrition at 3 month follow-up assessed longitudinal analysis of missing data (7.4.1.2.).

#### 7.4.1.1. Missing data within and between questionnaires

In terms of baseline missing data between questionnaires, there were data missing from 7 participants who had completed follow-up measures, resulting in 67 participants with complete data (9% missing data). There were no data missing from the dependent variable (the EARS) for the 74 participants that completed 3 month follow-up measures. MVA assessed missing data within-questionnaires and found five independent variables with more than 5 percent missing data (SF-McGill present pain intensity, SF-McGill overall pain, Stroop 18-65 years, WTAR = 6%; and backwards digit span = 8%).

Separate variance t-tests showed two variables with t-test values greater than 2 or less than -2 [FABQ (work) and backwards digit span]. For backwards digit span, three variables showed t-test values ± 2 (HADS depression, t=2.1; Brief IPQ treatment control, t=2.2 and Brief IPQ understanding of illness, t=2.1). For FABQ (work), four variables showed t-test values ± 2 (Brief IPQ concern, t=-9.9; SF-McGill present pain intensity, t=-2.1; WTAR, t=2.2; and Stroop test 18-65 years, t=3.0). The further the t-value from ± 2, the greater the departure from randomness. All but one t-value were close to ± 2 and none had *p* values ≤.05. Therefore any departures from randomness appeared slight and non-significant. However, a high t-value for FABQ (work) and Brief IPQ concern (t=-9.9, p=.000) suggested a significantly large departure from random missingness. When values for FABQ (work) are present, average Brief IPQ concern score is 8. However, when values for FABQ (work) are missing, average Brief IPQ score is 10. This suggests that participants who had missing values on the FABQ (work) had higher concerns regarding their CLBP than participants who completed the FABQ (work) without any missing values. This indicates that there may be departures from random missingness as a result of observed variables in the dataset (i.e. that data may not be MCAR). However, Little's MCAR test was

non-significant, indicating that missing data may in fact be MCAR [$\chi_2 = 6.932$ (df = 259; p = 1.00)].

Missingness appears to be a result of observed variables in the dataset, and not unobserved values, therefore data are considered plausibly MAR. To assess missing data assumptions further, a sensitivity analysis compares the results of the main regression analysis (Regression 1) performed using listwise deletion (assuming MCAR) with results of the same analysis using MI (assuming MAR). Comparison of results (i.e. parameter estimates) for both regressions will demonstrate if the missingness mechanism deviates from MAR.

#### 7.4.1.2. Missing data due to attrition

Twenty-six (26%) participants did not complete data at 3 month follow-up. Table 1 compares the 74 (74%) participants who completed 3 month follow-up (Group 1) to the 26 participants who were lost to follow-up at 3 month assessment (Group 2). Means, standard deviations, *p* values and Cohen's *d* ES are provided in Table 16.

**Table 16.** ***Comparison of participants with 3 month follow-up data and participants lost to 3 month follow-up.***

| **Baseline Variable** | | **Group 1 (Follow-up)** | **Group 2 (No follow-up)** | **Test, *p* value and ES** |
|---|---|---|---|---|
| | | (n = 74) | (n = 26) | |
| **Gender** | Male | 16 (22) | 8 (31) | $\chi^2$ = .88 |
| | Female | 58 (78) | 18 (69) | *p* = .35 |
| | | | | *d* = .20 |
| **Education** | | (n = 74) | (n = 26) | |
| | Up to G.C.S.E. | 15 (20) | 10 (39) | $\chi^2$ = 3.40 |
| | Up to Graduate | 59 (80) | 16 (61) | *p* = .07 |
| | | | | *d* = .40 |
| **Age** (years) | | (n = 74) | (n = 26) | |
| | Mean | 39 | 40 | t = -.32 |
| | SD | 12 | 11 | *p* = .75 |
| | | | | *d* = .07 |
| **Duration of pain** (years) | | (n = 74) | (n = 26) | |
| | Mean | 6.5 | 5.5 | t = .70 |
| | SD | 6.6 | 4.4 | *p* = .49 |
| | | | | *d* = .17 |
| **Present pain** (McGill) | | (n = 72) | (n = 22) | |
| | Mean | 5.4 | 2.4 | t = -1.87 |
| | SD | 2.1 | 2.4 | *p* = .07 |
| | | | | *d* = -.40 |
| **Disability** (RMDQ) | | (n = 73) | (n = 26) | |
| | Mean | 8.1 | 11.3 | t = -2.8 |
| | SD | 4.7 | 5.6 | *p* = .006 |
| | | | | *d* = -.57 |
| **Distress** (HADS) | | (n = 72) | (n = 26) | |
| | Mean | 12.6 | 14.4 | t = -1.1 |
| | SD | 7.1 | 6.0 | *p* = .26 |
| | | | | *d* = -.23 |
| **Illness Perceptions** | | (n = 71) | (n = 26) | |
| (Brief IPQ) | Mean | 46.8 | 50.1 | t = -1.3 |
| | SD | 11.4 | 11.2 | *p* = .21 |
| | | | | *d* = -.26 |

| Baseline Variable | | Group 1 (Follow-up) | Group 2 (No follow-up) | Test, *p* value and ES |
|---|---|---|---|---|
| **Fear-avoidance exercise** | | (n = 71) | (n = 25) | |
| (FABQ) | Mean | 13.7 | 14.8 | t = -.98 |
| | SD | 5.0 | 5.0 | *p* = .33 |
| | | | | *d* = -.20 |
| **Fear-avoidance Work** | | (n = 71) | (n = 24) | |
| (FABQ) | Mean | 14.6 | 23.5 | t = -4.0 |
| | SD | 9.4 | 9.9 | *p* = .000 |
| | | | | *d* = -.83 |
| **Pain catastrophizing** | | (n = 72) | (n = 26) | |
| (PCS) | Mean | 15.5 | 20.6 | t = -2.0 |
| | SD | 11.3 | 11.6 | *p* = .05 |
| | | | | *d* = -.40 |
| **Pre-morbid IQ** | | (n = 71) | (n = 23) | |
| (WTAR) | Mean | 106.1 | 101.6 | t = 1.6 |
| | SD | 11.4 | 12.8 | *p* = .11 |
| | | | | *d* = .34 |
| **behavioural inhibition** (Stroop) | | (n = 56) | (n = 20) | |
| (18-49 years) | Mean | 103.2 | 98.2 | t = 1.8 |
| | SD | 9.4 | 13.1 | *p* = .07 |
| | | | | *d* = .42 |
| **behavioural inhibition** (Stroop) | | (n = 15) | (n = 3) | |
| (50-65 years) | Mean | 85.2 | 61 | t = 3.5 |
| | SD | 21.5 | 5.3 | *p* = .003 |
| | | | | *d* = 1.75 |
| **Planning ability** | | (n = 72) | (n = 24) | |
| (Zoo map total) | Mean | 2.4 | 1.5 | t = 3.39 |
| | SD | 1.07 | 1.3 | *p* = .001 |
| | | | | *d* = .70 |
| **Working memory** | | (n = 69) | (n = 23) | |
| (Backwards digit span) | Mean | 5.7 | 5.5 | t = .57 |
| | SD | 1.8 | 1.9 | *p* = .57 |
| | | | | *d* = .12 |

*Note.* ES = effect size.

Four baseline variables were found to be significantly different between Group 1 and Group 2. These variables were disability (RMDQ; $d$ = -.57, $U_3$ = 70), fear-avoidance beliefs in relation to work ($d$ = -.83, $U_3$ = 79), pain catastrophizing (PCS; $d$ = -.40, $U_3$ = 65) and planning ability (Zoo Map test; $d$ = .70, $U_3$ = 76). Cohen's $d$ effect sizes for the four variables were moderate to large (range $d$ = -.40 to -.83). Cohen's $U_3$ estimates indicate that mean disability scores in Group 1 are approximately 25 percentiles lower than mean disability scores in Group 2. Mean scores for Group 1 are approximately 30 percentiles lower for fear-avoidance beliefs in relation to work, approximately 15 percentiles lower for pain catastrophizing, and approximately 67 percentiles higher for planning ability when compared to scores in Group 2. These results suggest that participants who completed follow-up measures (Group 1) were less affected by disability, fear avoidance beliefs in relation to work and pain catastrophizing, and also had better executive functions in relation to planning ability, than participants who were lost to 3 month follow-up (Group 2).

There were no significant differences between the two groups for the remaining variables. However, there were three non-significant variables that had moderate effect sizes (≥ $d$ = ±.40). These three variables were education ($d$ = .40, $U_3$ = 65), the Stroop test (18-49 years) ($d$ = .42, $U_3$= 66) and SF-MPQ present pain ($d$ = -.40, $U_3$ = 65). Cohen's $U_3$ estimates indicate that mean scores for Group 1 are approximately 15 percentiles higher than the average participant in Group 2 for education and the Stroop test (18-49 years). Additionally, mean scores for Group 1 are approximately 15 percentiles lower than the average participant in Group 2 for level of present pain. This suggests that participants in Group 1 had lower levels of pain, were better educated and had better executive functions in relation to behavioural inhibition than participants in Group 2.

Differences in observed characteristics between Group 1 and Group 2 indicate that data are likely not MCAR. Furthermore, these results provide evidence that missing data are related in part to observed data values, which begins to satisfy the MAR assumption. Therefore, listwise deletion of data (which assumes data are MCAR) for subsequent analysis may provide biased results, as the sample is unlikely to be representative of the population. Overall analyses of missing

data suggest that missingness appears to be a result of observed variables in the dataset and therefore, it is unlikely that missing data are MCAR.

### 7.4.2. Research Objective 4

The fourth research objective investigates the role of executive function factors in adherence to prescribed home exercise in CLBP. The two hierarchical regression models (Regression 1 and Regression 2) test the hypothesis that executive function factors explain additional variance in adherence behaviour over and above variance that is explained by psychosocial and clinical factors. Further regression analyses (Regressions 3 to 8) explore the predictive value of executive functions on specific areas of adherence as assessed by the EARS. Main assumptions of multiple regression were tested prior to analyses (Field, 2009; Tabachnick & Fidell, 2007). Firstly, normality, linearity and homoscedasticity of residuals in relation to the relevant variables are discussed (7.4.2.1.). Discussion then focuses on selection of variables for entry into the two hierarchical regression models (7.4.2.2.). Subsequent to this, the first hierarchical regression analysis was repeated using 5 MI as a sensitivity analysis (7.4.2.3.). Multiple regression models 3 to 8 then explore the predictive value of executive functions on specific areas of adherence as assessed by the six individual EARS items (7.4.2.4.).

#### 7.4.2.1. Normality, linearity, homoscedasticity of residuals

Assessment of homoscedasticity of residuals using the Levene statistic found that age showed a significant result ($p < .05$), thus potentially violating this assumption. A residual scatterplot was produced to assess further the issue of heteroscedasticity. The scatterplot showed no correlation between predicted values and residuals, thus confirming that there is no general issue of heteroscedasticity in the sample. Therefore, no further action was taken. The assumption of independence of errors was assessed using the Durbin-Watson (*d*) statistic as a measure of autocorrelation in the residuals. This resulted in $d$=2.348, indicating that the residuals were uncorrelated (Field, 2009).

#### 7.4.2.2. Selection of variables for the hierarchical regression models

Subsequent to thorough testing of the assumptions of multiple regression analysis, variables were selected for entry into two hierarchical regression models using theoretical and statistical rationales. Theoretical rationale for selection of variables was based on the notion that executive functions predict additional adherence behaviour over and above variance in adherence behaviour that is explained by clinical and psychosocial variables. Statistical rationale was based on ES resulting from Pearson's product-moment correlational analyses. Spearman's rank correlation coefficients were compared to Pearson's correlations for one non-normally distributed variable (i.e. the Zoo Map test 'execution' sub-scale score). Pearson's correlations showed a stronger association between Zoo Map test 'execution' and adherence (the EARS) (r = .063, *p* = .59) compared to Spearman's correlations (r = .035, *p* = .77). The non-normal variable showed a very weak ES in relation to adherence and the difference between both correlation analysis (r=.028) was deemed negligible. Furthermore, it seemed most appropriate to use Pearson's correlations as they rely on the same assumptions as multiple regression (e.g. regarding linearity between the independent and dependent variables). Regression 1 included total-score independent variables (7.4.2.2.1.). Regression 2 included sub-scale score independent variables in an attempt to further explore predictors of exercise adherence behaviour (7.4.2.2.2.). The results of both hierarchical regression analyses are summarized at the end of Regression 2 (7.4.2.2.3.).

##### 7.4.2.2.1. Regression 1

Table 17 shows the results of Pearson's product-moment correlations (r) and point-biserial correlation coefficients ($r_{pb}$) between total-score independent variables and adherence (the EARS). Three demographic variables (gender, age and education) were included. Due to space constraints, only variables that met inclusion criteria for entry into the regression model (i.e. r ≥ .2) are included in Table 17. A detailed table of correlations is displayed in Appendix 16.

**Table 17.** ***Correlations between demographic variables, total-score independent variables and dependent variable***

| Variable | EARS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Gender | -.268* | 1 | | | | | | | | | | | |
| 2. Age | -.121 | -.079 | 1 | | | | | | | | | | |
| 3. Education | -.074 | .131 | -.338** | 1 | | | | | | | | | |
| 4. Duration | -.326** | .033 | .270** | -.117 | 1 | | | | | | | | |
| 5. General | -.316** | .132 | .161 | -.192 | .210* | 1 | | | | | | | |
| 6. HADS | -.243* | .364** | -.114 | -.008 | .079 | .377** | 1 | | | | | | |
| 7. B-IPQ | -.235* | .330** | .192 | -.138 | .158 | .343** | .545** | 1 | | | | | |
| 8. PCS total | -.248* | .254* | .057 | -.139 | -.015 | .249* | .646** | .614** | 1 | | | | |
| 9. RMDQ | -.252* | .173 | .318** | -.132 | .188 | .281** | .540** | .624** | .626** | 1 | | | |
| 10. SF-MPQ | -.255* | .072 | .217* | -.099 | .000 | .139 | .275** | .438** | .423** | .496** | 1 | | |
| 11. SF-MPQ | -.344** | .135 | .235* | -.267** | .200 | .185 | .338** | .518** | .418** | .581** | .565** | 1 | |
| 12. Zoo Map | .215 | .123 | -.280** | .296** | -.081 | -.174 | -.118 | -.187 | -.166 | -.273** | -.193 | -.174 | 1 |

*Note:* *p<.05. **p<.01. *** p<.001.

Table 17 shows range of ES from r = 0 (FABQ work) to r = -.344 (present pain intensity). No variables were highly correlated (r ≥ .5). Present pain intensity (r=-.344) and overall pain (r=-.255) both met statistical inclusion criteria, however present pain intensity was selected for entry into the model due to its stronger relationship with adherence. Gender was the only covariate variable that met entry criteria. However, age and education were selected as additional covariates due to their relationships with executive functions (i.e. Zoo Map test and age, r = -.280; Zoo Map test and education, r = .296). This resulted in 11 independent variables for entry into the first hierarchical regression model, with total EARS score (adherence) as the dependent variable. There were three demographic variables (gender, age and education), four psychosocial variables (general health, HADS distress, Brief IPQ total and PCS total), three clinical variables (RMDQ disability, SF-MPQ present pain intensity and duration of pain) and one executive function variable (Zoo Map test). The 11 variables were entered into the regression in three steps. These steps are discussed in relation to statistical rationale (i.e. Pearson's correlations) with the addition of adjunct theoretical rationale specific to the order of entry of variables.

**Step 1**

It is recommended that static variables are entered first and that dynamic variables are entered in subsequent steps when constructing a hierarchical regression model (Cohen et al., 1983). Therefore, covariate variables were entered in the first step of the model (i.e. gender, age and education). This allowed for effects of the covariates to be controlled for prior to the entry of psychosocial, clinical and executive function variables.

**Step 2**

As it is theorised that executive functions will predict additional adherence behaviour over and above variance in adherence behaviour that is explained by clinical and psychosocial variables, the latter variables that met statistical inclusion criteria were entered in the second step (i.e. general health, HADS distress, Brief IPQ total and PCS total, RMDQ disability, SF-MPQ present pain intensity and duration of pain). In addition to controlling for the effects of these variables prior to the next stage of the model, it seemed logical to enter these

variables together as they are theorised to have an indirect effect on behaviour. For example, theory posits that that illness perceptions (Leventhal et al., 1984) and pain catastrophizing (Sullivan et al., 1995) influence behaviour indirectly by firstly influencing coping behaviour. With regards to duration of pain, present pain and distress, neurological changes in individuals with CLBP have been shown to be larger in relation to higher levels of these three variables (Chapter 1). Thus, it is posited that these variables affect neurological changes which firstly influence executive functions and then directly influence adherence behaviour. Entering these variables in the second step of the model allowed for the effects of these variables to be controlled for prior to entering executive function variables that are theorised to directly affect adherence behaviour.

**Step 3**

The Zoo Map test was the only executive function variable to meet statistical entry criteria for the regression model. Therefore the Zoo Map test was the sole variable entered in the third and final stage of the regression model, after the effects of covariate, clinical and psychosocial variables were controlled for in the earlier two stages. The results of the hierarchical regression analysis are shown in Table 18.

**Table 18*. First hierarchical regression analysis using listwise deletion of data (n=69).***

| | Unstandardized Coefficients | | Standardized Coefficients | |
|---|---|---|---|---|
| **Model** | **B** | **SE B** | **β** | **Sig.** |
| **Step 1** | | | | |
| Constant | 14.648 | 3.490 | - | .000 |
| Gender | 4.925 | 1.816 | .318 | .009** |
| Age | -.090 | .066 | -.169 | .175 |
| Education | -1.799 | 2.000 | -.111 | .372 |
| **Step 2** | | | | |
| Constant | 22.670 | 5.015 | - | .000 |
| Gender | 3.905 | 1.927 | .252 | .047* |
| Age | -.082 | .076 | -.154 | .287 |
| Education | -4.157 | 1.954 | -.256 | .038* |
| Duration of pain | -.291 | .120 | -.298 | .019* |
| RMDQ disability | .331 | .269 | .224 | .224 |
| SF-MPQ present pain | -.983 | .436 | -.312 | .028* |
| HADS distress | -.098 | .157 | -.104 | .533 |
| Brief IPQ | .084 | .097 | .146 | .388 |
| PCS total | -.078 | .107 | -.132 | .465 |
| General health | -1.165 | .882 | -.172 | .191 |
| **Step 3** | | | | |
| Constant | 19.626 | 5.757 | - | .001 |
| Gender | 4.030 | 1.928 | .260 | .041* |
| Age | -.063 | .078 | -.119 | .422 |
| Education | -4.413 | 1.966 | -.271 | .029* |
| Duration of pain | -.292 | .120 | -.298 | .018* |
| RMDQ disability | .341 | .269 | .231 | .210 |
| SF-MPQ present pain | -.995 | .435 | -.316 | .026* |
| HADS distress | -.070 | .159 | -.074 | .661 |
| Brief IPQ | .088 | .097 | .153 | .365 |
| PCS total | -.083 | .107 | -.140 | .440 |
| General health | -1.100 | .883 | -.162 | .218 |
| Zoo Map test | .796 | .742 | .128 | .288 |

*Note.* * $p < .05$. ** $p < .01$.

Table 18 shows that after the three covariate variables were entered in Step 1, the model was statistically significant [F(3,65) = 2.99, p = .037] and explained 12.2 percent of the variance in adherence behaviour ($R^2$ = .122). After entry of the clinical and psychosocial variables in Step 2, the model as a whole explained 32.8 percent of the variance in adherence behaviour ($R^2$ = .328). The introduction of clinical and psychosocial variables explained an additional 21.4 percent of the variance in exercise adherence, after controlling for covariate variables ($\Delta R^2$ = .214) [F(10,58) = 2.82, p = .006]. After the addition of executive functions in Step 3, the overall model accounted for 34.1 percent of the variance in adherence to prescribed exercise ($R^2$ = .341) [F(12,56) = 2.47, p = .011].

Executive functions explained 1.3 percent of additional variance in adherence behaviour over and above that explained by clinical and psychosocial variables. The addition of the Zoo Map test in Step 3 of the model was non-significant and showed only a small relationship with adherence (β = .128, p=.288). The hypothesis that executive functions predict additional variance in adherence behaviour over and above that which is predicted by clinical and psychosocial variables was not supported. In terms of providing unique variance in the final model, present pain intensity had the largest ES and therefore had the most impact on the model (β = -.316, p=.026). This was followed by duration of pain (β = -.298, p=.018), education (β = -.271, p=.029) and gender (β = .260, p=.041). The seven remaining variables all had weak ES and did not make a significant contribution to the model (p < .05). After the executive function variable in Step 3 was included, the model as a whole explained 34.1 percent of the variance in adherence behaviour. The B coefficient for gender indicates that men are more adherent to prescribed home exercise than women (B=4.030). Men score on average 4 points higher on the EARS than women, when all other variables are controlled for.

#### 7.4.2.2.2. Regression 2 – Bootstrapped model

This regression model was bootstrapped due to the inclusion of a non-normal variable (Zoo Map test 'execution'). The Zoo Map test total score met normality assumptions. Therefore, the previous model did not require bootstrapping. Table 19 shows the results of Pearson's product-moment correlations (r) and point-biserial correlation coefficients ($r_{pb}$) between sub-scale variables (that relate to the total-score variables that were included in the first model) and adherence (the EARS). Demographic variables and variables that met inclusion criteria for entry into the standard multiple regression model are included (i.e. r ≥ .2). ESs in Table 19 range from r = .070 (zoo map execution) to r = -.344 (present pain intensity).

**Table 19*. Correlations between demographic variables, sub-scale score independent variables and dependent variable (EARS)***

| Variable | EARS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Gender | -.268* | 1 | | | | | | | | | | | | | | |
| 2. Age | -.121 | -.079 | 1 | | | | | | | | | | | | | |
| 3. Education | -.074 | .131 | -.338** | 1 | | | | | | | | | | | | |
| 4. Duration of pain | .326** | .033 | .270** | -.117 | 1 | | | | | | | | | | | |
| 5. General health | .316** | .132 | .161 | -.192 | .210* | 1 | | | | | | | | | | |
| 6. HADS anxiety | -.216 | .377** | -.147 | .054 | .002 | .239* | 1 | | | | | | | | | |
| 7. HADS depression | -.234* | .283** | -.056 | -.077 | .152 | .464** | .669** | 1 | | | | | | | | |
| 8. B-IPQ timeline | -.257* | .300** | .132 | -.080 | .420** | .389** | .327** | .455** | 1 | | | | | | | |
| 9. B-IPQ emotional | -.251* | .349** | .210* | -.061 | .099 | .271** | .489** | .533** | .388** | 1 | | | | | | |
| 10. PCS helplessness | -.278* | .309 | -.009 | -.103 | .004 | .237* | .542** | .603** | .402** | .638** | 1 | | | | | |
| 11. PCS rumination | -.201 | .152 | .138 | -.179 | .000 | .247* | .547** | .500** | .366** | .631** | .831** | 1 | | | | |
| 12. RMDQ disability | -.252* | .173 | .318* | -.132 | .188 | .281** | .427 | .567** | .434** | .580** | .643** | .568** | 1 | | | |
| 13. SF-MPQ present pain | -.344** | .135 | .235** | -.267** | .200 | .185 | .261* | .366** | .243* | .430** | .427** | .375** | .581** | 1 | | |
| 14. Zoo Map formulation | .079 | .071 | -.125 | .175 | .010 | -.167 | -.168 | -.140 | -.097 | -.181 | -.189 | -.177 | -.282** | -.144 | 1 | |
| 15. Zoo Map execution | .070 | .009 | -.145 | .316** | .053 | -.107 | -.203* | -.071 | -.193 | -.102 | -.094 | -.206* | -.142 | -.001 | .241* | 1 |

*p<.05. **p<.01.

PCS helplessness and PCS rumination were highly correlated (r=.831), therefore helplessness was selected for entry into the model due to its larger relationship with adherence (r=-.278). Demographic and clinical variables remained the same as in the first regression. This resulted in 14 independent variables for entry into the second regression model. These were three demographic variables (gender, age and education), three clinical variables (RMDQ disability, SF-MPQ present pain intensity and duration of pain), six psychosocial variables (general health, HADS depression, HADS anxiety, Brief IPQ timeline, Brief IPQ emotional response and PCS helplessness), and two executive function variables (Zoo Map test 'formulation' and Zoo Map test 'execution'). The 14 variables were entered into the regression in the same three steps described for Regression 1.

Covariate variables were entered in the first step of the model (i.e. gender, age and education). Variables entered in the second step were general health, HADS depression, HADS anxiety, Brief IPQ timeline, Brief IPQ emotional response, PCS helplessness, RMDQ disability, SF-MPQ present pain intensity and duration of pain. The two Zoo Map test sub-scales were entered in Step 3 ('formulation' and 'execution'), after the effects of covariate, clinical and psychosocial variables were controlled for in the earlier two stages. Results of Regression 2 are summarised in Table 20. Standard errors (SE B) are reported for the bootstrapped model and the model without bootstrapping for comparison purposes.

**Table 20.** ***Second hierarchical regression analyses using listwise deletion of data.***

| | Unstandardized Coefficients | | | Standardized Coefficients | |
|---|---|---|---|---|---|
| **Model** | **B** | **SE B** | **SE B (Bootstrap)** | **β** | **Sig.** |
| **Step 1** | | | | | |
| Constant | 14.648 | 3.490 | 3.256 | - | .000 |
| Gender | 4.925 | 1.816 | 1.811 | .318 | .009** |
| Age | -.090 | .066 | .058 | -.169 | .175 |
| Education | -1.799 | 2.000 | 2.106 | -.111 | .372 |
| **Step 2** | | | | | |
| Constant | 23.203 | 4.836 | 5.480 | - | .000 |
| Gender | 3.996 | 2.006 | 2.044 | .258 | .051 |
| Age | -.094 | .080 | .085 | -.177 | .243 |
| Education | -4.373 | 1.974 | 2.032 | -.269 | .031* |
| General health | -1.222 | .950 | .957 | -.180 | .203 |
| Duration of pain | -.341 | .130 | .113 | -.349 | .011* |
| HADS anxiety | -.013 | .264 | .259 | -.008 | .961 |
| HADS depression | -.257 | .382 | .387 | -.135 | .504 |
| Brief IPQ timeline | .435 | .401 | .414 | .170 | .284 |
| Brief IPQ emotional identity | .149 | .411 | .397 | .055 | .719 |
| PCS helplessness | -.249 | .229 | .266 | -.205 | .283 |
| SF-MPQ present pain | -.890 | .427 | .432 | -.282 | .042* |
| RMDQ disability | .418 | .289 | .339 | .284 | .153 |
| **Step 3** | | | | | |
| Constant | 20.620 | 6.120 | 6.892 | - | .001 |
| Gender | 3.885 | 2.045 | 2.122 | .251 | .063 |
| Age | -.087 | .082 | .089 | -.164 | .292 |
| Education | -4.954 | 2.161 | 2.158 | -.304 | .026* |
| General Health | -1.170 | .971 | 1.005 | -.172 | .234 |
| Duration of pain | -.344 | .132 | .120 | -.351 | .012* |
| HADS anxiety | .049 | .282 | .273 | .031 | .862 |
| Brief IPQ timeline | .434 | .407 | .421 | .170 | .291 |
| Brief IPQ emotional identity | .142 | .417 | .425 | .053 | .735 |
| PCS helplessness | -.232 | .234 | .282 | -.191 | .327 |
| SF-MPQ present pain | -.981 | .452 | .483 | -.311 | .034* |
| RMDQ disability | .442 | .296 | .354 | .300 | .141 |
| Zoo Map formulation | .027 | .270 | .287 | .012 | .921 |
| Zoo Map execution | .362 | .523 | .554 | .091 | .493 |

*Note.* * $p < .05$. ** $p < .01$.

Table 20 shows that after the three covariate variables were entered in Step 1, the model was statistically significant [$F(3,65) = 2.99$, $p = .037$] and explained 12.2 percent of the variance in adherence behaviour ($R^2 = .122$). After entry of the clinical and psychosocial variables in Step 2, the model as a whole explained 34.3 percent of the variance in adherence behaviour ($R^2 = .343$). The introduction of clinical and psychosocial variables explained an additional 22.1 percent of the variance in exercise adherence, after controlling for covariate variables ($\Delta R^2 = .202$) [$F(12, 56) = 2.43$, $p = .013$]. This is 1.5 percent more variance explained by sub-scale variables than the total-score variables in Regression 1. After the addition of executive functions in Step 3, the overall model accounted for 34.9 percent of the variance in adherence to prescribed exercise ($R^2 = .349$) [$F(14,54) = 2.06$, $p = .029$]. This is 0.8 percent more variance in adherence behaviour than that explained by Regression 1.

In this regression model, executive functions explained 0.6 percent of additional variance in adherence behaviour over and above that explained by clinical and psychosocial variables. Addition of the two Zoo Map test sub-scales in Step 3 of the model was not significant and showed weaker relationships with adherence compared to the combined Zoo Map test in Regression 1 ('formulation': $\beta = .012$, $p=.921$; 'execution': $\beta = .091$, $p=.493$). In terms of providing unique variance in the final model, duration of pain had the largest ES and therefore had the most impact on the model ($\beta = -.351$, $p=.012$). This was followed by present pain intensity ($\beta = -.311$, $p=.034$). In the first regression model, present pain intensity had a larger ES than duration of pain. However, the two remaining variables in Regression 2 with an ES $r \geq .2$ provided less unique variance to the model in the same order as in Regression 1. These variables were education ($\beta = -.304$, $p=.026$) and gender ($\beta = .251$, $p=.063$). The seven remaining variables all had weak ES and did not make a significant contribution to the model ($p < .05$). After the executive function variables in Step 3 were included, the model as a whole explained 34.9 percent of the variance in adherence behaviour. Bootstrapping this regression model only marginally changed standard errors produced by the model. This suggests that the distribution of the non-normal variable (i.e. Zoo Map execution) did not bias the results.

#### 7.4.2.2.3. Summary for Regression 1 and Regression 2

The fourth research objective was to evaluate the possible roles of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in CLBP. This was tested by construction of two hierarchical multiple regression models with predictors based on theoretical and statistical rationales. Regression 1 and 2 indicate that longer duration of pain, higher present pain, lower level of education and being female, all play a role in predicting non-adherence to prescribed exercise. Results of the two hierarchical regressions do not support the hypothesis that executive functions predict additional variance in adherence behaviour over and above that which is predicted by clinical and psychosocial variables. Additional explained variance by executive functions was not significant and only had a small impact on the overall model. Furthermore, results suggest that the executive function measure used in the present research (the Zoo Map test) is better used as a general measure of planning, rather than assessment of two sub-types of planning, when attempting to predict non-adherence to prescribed exercise.

### 7.4.2.3. Sensitivity analysis

The first hierarchical regression analysis was repeated using 5 MI datasets and a chained equations approach to probe whether relaxing the assumption of MCAR for the small number with missing baseline data impacted substantially on the estimates. SPSS does not provide pooled data for statistics that are not computed using standard errors. Therefore, arithmetic means for standardised beta coefficients (β) were calculated to provide approximate pooled estimates for MI data. Appendix 17 shows the results of the MI hierarchical regression. Pooled unstandardized beta coefficients (B) are discussed in relation to ES as they account for the additional uncertainty due to being imputed. ES were found to be similar in both the first regression analysis and the sensitivity analysis. The range of standardised β coefficients are provided to give an indication as to where the standardised pooled β estimates may lie. Ranges for the pooled β estimates were small. Furthermore, estimates were similar across the models. Appendix 18 shows that $R^2$ is similar across the models. Arithmetic means for $R^2$ and $\Delta R^2$ can be compared to the main regression analysis in Table 21.

**Table 21.** ***R statistics from main analysis and sensitivity analysis.***

| Statistic | Main regression analysis | Sensitivity analysis[ł] |
|---|---|---|
| **$R^2$** | | |
| Step 1 | .122 | .141 |
| Step 2 | .328 | .418 |
| Step 3 | .341 | .437 |
| **Adj. $R^2$** | | |
| Step 1 | .081 | .114 |
| Step 2 | .212 | .338 |
| Step 3 | .214 | .352 |
| **$\Delta$ $R^2$** | | |
| Step 1 | .122 | .141 |
| Step 2 | .206 | .277 |
| Step 3 | .013 | .019 |

*Note.* [ł] Arithmetic means calculated for multiply imputed data

Overall variance explained by each model is larger for the multiply imputed dataset (Step 1 = 1.9% difference, Step 2 = 7.5% difference and Step 3 = 8.5% difference). However, differences in variance explained by both regressions are negligible in terms of amount of additional variance explained by each model (Table 6, $\Delta$ $R^2$). Overall, similarities between the first hierarchical regression and the sensitivity analysis indicate that parameter estimates (B) in the first regression are not biased. Results for all independent variables remained robust when data were tested under different missing data assumptions (i.e. MCAR for regression using listwise deletion and MAR for regression using MI data). Therefore, results of the hierarchical regressions using listwise deletion of data are assumed to be unbiased.

#### 7.4.2.4. Further exploration of executive functions and adherence behaviour

Multiple regression models 3 to 8 explore the predictive value of executive functions on specific areas of adherence as assessed by the six individual EARS items (see Appendix 19). Executive functions did not predict adherence

to prescribed home exercise in the preceding regression models. Therefore, executive functions are not expected to be strong predictors of individual EARS items in subsequent regression models once demographic factors are controlled for. However, these regressions may provide novel information regarding areas of executive function that influence specific aspects of adherence behaviour.

Pearson's correlations assessed relationships between the three demographic variables used in Regressions 1 and 2, the four executive function variables and the six individual EARS items (Table 22). EARS items 1 to 6 refer to the following domains of adherence behaviour: I do my exercises as often as recommended (EARS 1), I forget to do my exercises (EARS 2), I do less exercise than recommended by my health care professional (EARS 3), I fit exercise into my regular routine (EARS 4), I don't get around to doing my exercises (EARS 5) and I do some, but not all, of my exercises (EARS 6).

**Table 22.** ***Correlations between demographic variables, executive function variables and six EARS items***

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. EARS 1 | 1.000 | | | | | | | | | | | | |
| 2. EARS 2 | .732** | 1.000 | | | | | | | | | | | |
| 3. EARS 3 | .642** | .645** | 1.000 | | | | | | | | | | |
| 4. EARS 4 | .531** | .577** | .449** | 1.000 | | | | | | | | | |
| 5. EARS 5 | .746** | .778** | .758** | .672** | 1.000 | | | | | | | | |
| 6. EARS 6 | .414** | .479** | .569** | .190** | .445** | 1.000 | | | | | | | |
| 7. Gender | -.209 | -.269* | -.169 | -.103 | -.222 | -.328** | 1.000 | | | | | | |
| 8. Age | -.132 | -.105 | -.166 | -.021 | -.049 | -.099 | -.079 | 1.000 | | | | | |
| 9. Education | .008 | .032 | -.048 | .007 | -.080 | -.275* | .131 | -.338** | 1.000 | | | | |
| 10. WTAR | .088 | .125 | .028 | .011 | -.064 | -.073 | -.187 | -.294** | .620** | 1.000 | | | |
| 11. Stroop test | .007 | .006 | -.039 | -.021 | -.091 | .054 | .076 | -.549** | .307** | .370** | 1.000 | | |
| 12. Zoo Map test | .201 | .168 | .207 | .078 | .213 | .147 | .123 | -.280** | .296** | .320** | .414** | 1.000 | |
| 13. Digit span B/W | .034 | .123 | .013 | .064 | -.025 | .048 | -.163 | -.208* | .316** | .506** | .354** | .311** | 1.000 |

*p<.05. **p<.01.

The Zoo Map test was the only executive function variable to show an ES of r ≥ .2 with any individual EARS items. These items were EARS 1 (exercise as often as recommended), 3 (exercise less than recommended) and 5 (don't get around to exercising), which all showed weak, positive relationships with the Zoo Map test (r=.201, r=.207 and r=.213 respectively). These correlations suggest that better planning ability is related to exercising as often as recommended (i.e. better adherence to prescribed home exercise). Conversely, better planning ability appears to also be related to exercising less than recommended and not getting around to exercising (i.e. poorer adherence to prescribed home exercise). Reasons for these opposing results may be that a factor other than planning ability that is assessed by the Zoo Map test is related to exercise adherence behaviour. Alternatively, it may be that a construct other than adherence behaviour is assessed by the EARS and may explain relationships found in Table 22.

Education and gender displayed an ES of r ≥ .2 with EARS items 2 (forgetting) and 6 (doing some of my exercises). Education displayed a weak, negative relationship with EARS item 6. Gender displayed moderate, negative relationships with EARS items 2 and 6. Additionally, age and education displayed a small to large ES r ≥ .2 with all four executive function factors ($p<.05$). Age was negatively correlated, and education was positively correlated, with all four executive function factors. These results were expected based on vast research literature demonstrating that poorer executive functioning is associated with older age (e.g. Salthouse, 2009) and lower levels of education (e.g. Plassman et al., 1995).

**Regression 3**

The dependent variable for the third regression was item 1 of the EARS (I exercise as often as recommended by my healthcare professional). After the three covariate and four executive function variables were entered into the regression model, executive functions explained 10.5 percent of the variance in adherence behaviour based on item 1 ($R^2 = .105$). Executive functions (plus covariate variables) did not explain a significant amount of variance in adherence behaviour [$F(7,59) = .984$, $p = .452$]. Gender was the only variable

with an ES β ≥ .2 (β=.263, p=.059), closely followed by age (β=-.178, p=.243). ES for the remaining variables ranged from β=.140 (Zoo Map total) to β= -.015 (WTAR).

**Regression 4**

The dependent variable for the fourth regression was item 2 of the EARS (I forget to do my exercises). After the three covariate and four executive function variables were entered into the regression model, executive functions explained 13 percent of the variance in adherence behaviour based on item 2 ($R^2$ = .130). This was a small increase in explained variance over the previous regression model (Regression 3). Executive functions (plus covariate variables) did not explain a significant amount of variance in adherence behaviour [F(7,59) = 1.264, p = .284]. Gender and the Zoo Map test showed ES β ≥ .2 (gender, β=.273, p=.047 and Zoo Map test β=.210, p=.119). This was followed by the Stroop test (18-65 years) (β=-.173, p=.225). ES for the remaining variables ranged from β=-.142 (age) to β= .047 (education).

**Regression 5**

The dependent variable for the fifth regression was item 3 of the EARS (I do less exercise than recommended by my healthcare professional). After the three covariate and four executive function variables were entered into the regression model, executive functions explained 13.6 percent of the variance in adherence behaviour based on item 3 ($R^2$ = .136). This was a small increase in explained variance over the previous two regression models (Regressions 3 and 4). Executive functions (plus covariate variables) did not explain a significant amount of variance in adherence behaviour [F(7,59) = 1.328, p = .254]. Age and gender showed ES β ≥ .2 (age, β=-.267, p=.076 and gender β=.205, p=.132). This was followed by the Zoo Map test (β=.190, p=.157). ES for the remaining variables ranged from β=-.168 (the Stroop test, 18-65 years) to β= -.031 (WTAR).

**Regression 6**

The dependent variable for the sixth regression was item 4 of the EARS (I fit my exercises into my regular routine). After the three covariate and four executive

function variables were entered into the regression model, executive functions explained 3 percent of the variance in adherence behaviour based on item 4 ($R^2$ = .030). This model explains between 7.5 and 10.6 percent less variance in adherence behaviour than the previous three regression models (Regressions 3, 4 and 5). Executive functions (plus covariate variables) did not explain a significant amount of variance in adherence behaviour [F(7,59) = .261, p = .966]. No variables showed an ES of β ≥ .2. ES for all variables ranged from β=.123 (backwards digit span) to β=-.020 (age).

**Regression 7**

The dependent variable for the seventh regression was item 5 of the EARS (I don't get around to doing my exercises). After the three covariate and four executive function variables were entered into the regression model, executive functions explained 15.4 percent of the variance in adherence behaviour based on item 5 ($R^2$ = .154). This model explains more variance in adherence behaviour than the previous four regression models (Regressions 3, 4, 5 and 6). Executive functions (plus covariate variables) did not explain a significant amount of variance in adherence behaviour [F(7,59) = 1.531, p = .175]. Similarly to Regression 4, gender and the Zoo Map test showed ES β ≥ .2 (gender, β=.289, p=.033 and Zoo Map test β=.248, p=.063). This was followed by the WTAR (β=-.188, p=.284). ES for the remaining variables ranged from β=-.147 (the Stroop test, 18-65 years) to β= -.017 (backwards digit span).

**Regression 8**

The dependent variable for the eighth regression was item 6 of the EARS (I do some, but not all, of my exercises). After the three covariate and four executive function variables were entered into the regression model, executive functions explained 28.8 percent of the variance in adherence behaviour based on item 6 ($R^2$ = .288). This model explains between 13.4 and 23.8 percent more variance in adherence behaviour than the other five regression models. Executive functions (plus covariate variables) explained a significant amount of variance in adherence behaviour [F(7,59) = 3.409, p = .004]. Gender, education, age and the Zoo Map test showed ES β ≥ .2 (gender, β=.376; p=.003, education; β=-.298, p=.032, age, β=-225, p=.099 and the Zoo Map test β=.202, p=.098). ES

for the remaining variables ranged from β=-.113 (WTAR) to β= -.006 (backwards digit span).

#### 7.4.2.4.1. Summary of regression models 3 to 8

Regressions 3 to 8 assessed how much variance in adherence behaviour could be explained by the four executive function measures used in the present study (WTAR, the Stroop test, the Zoo Map test and the backwards digit span). Each of the six EARS items, assessing different domains of adherence, acted as a dependent variable for each of the six regressions. Based on a small ES of β ≥ .2, results indicate that of the executive function measures, planning ability (Zoo Map test) is the best predictor of adherence to prescribed exercise in CLBP. Planning ability partially predicted non-adherence to exercise in relation to forgetting, not getting around to exercising and doing some, but not all, of the prescribed exercises. Executive functions with ES between .15 and .2 can be argued to have a minor, but notable, impact on two dimensions of adherence. Inhibition (the Stroop test) had a small impact on forgetting to exercise and doing less exercise than recommended. Pre-morbid IQ (WTAR) had a small impact on not getting around to exercising. Covariate variables played a predictive role for all EARS items but one (I fit my exercises into my regular routine). Gender had the greatest impact out of all variables on all EARS items except for one, where age predicted greater variance in behaviour (I do less exercise than recommended by my healthcare professional). All variables had a particularly weak impact in terms of predicting adherence behaviour in relation to fitting exercise into a regular routine (β<.123).

### 7.4.3. Research Objective 5: Analysis of clinical variables

The fifth research objective was to determine whether adherence to prescribed home exercise is related to clinical outcome. Change scores for pain and disability are reported (7.4.3.1.) and relationships between clinical factors and adherence behaviour are examined using correlational analysis (7.4.3.2.). Issues relating to attrition are considered in relation to these results.

#### 7.4.3.1. Change in pain and disability over time

Change scores are reported for SF-MPQ present pain intensity and RMDQ disability at 3 months. Changes in disability are discussed in relation to clinically significant change. Range, mean and standard deviations for change scores at 3 months can be seen in Table 23. Changes in present pain intensity over 3 months ranged from a maximum decrease of -6 points to a maximum increase of 5 points. Average change in pain for the sample was a decrease in pain of -.1.47 points (n=72). Changes in disability over 3 months ranged from a maximum decrease of 10 points and a maximum increase of 5 points. Average change in disability for the sample was a decrease in disability of -.2.25 points (n=73). As the average change score is between 2 and 3 points, this can be argued to be clinically significant according to Patrick and colleagues (1995).

**Table 23.** ***Descriptive statistics for pain and disability change scores at 3 months***

| | **n** | **range** | **ẋ (SD)** |
|---|---|---|---|
| Present pain intensity (SF-MPQ) | 72 | 11 (-6 to 5) | -1.47(1.8) |
| Disability (RMDQ) | 73 | 15 (-10 to 5) | -2.25 (2.8) |

With regards to present pain intensity, pain had decreased in 80 percent of the sample at 3 months. Most of these participants showed a decrease of 1 point (36%) and smaller numbers showed larger improvements (24% = 2 point reduction, 10% = 3 point reduction, 3% = 4 point reduction, 6% = 5 point reduction and 1% = 6 point reduction). Eight percent of the sample's present pain intensity score remained the same. The remaining 12 percent of the sample showed an increase in pain. Seven percent showed a 1 point increase, three percent showed a 2 point increase and two percent showed a five point increase in pain scores. With regards to disability scores, 74 percent of the sample reported a decrease in disability at 3 months. Sixty percent of these participants showed a clinically significant decrease in disability (i.e. ≥ 2 points). Of this 60 percent of the sample, 19 percent showed a decrease in disability of 2 to 3 points, whereas smaller numbers of participants showed larger improvements (15% = 3-4 point reduction, 7% = 4-5/5-6 point reductions, 3% 6-7/7-8/8-9 point reduction, and 1% 9-10 point reduction). Fifteen percent of the sample's disability scores remained the same. The remaining 11 percent of the sample showed an increase in disability. Seven percent showed a 1 point increase, one percent showed a 3 point increase and three percent showed a five point increase in disability scores.

It is important to consider the impact of attrition when interpreting these results. Differences were found between completers (Group 1) and non-completers (Group 2) of 3 month follow-up measures. For example, Group 2 displayed higher pain and disability at baseline, demonstrating that attrition data were unlikely MCAR. Understanding how results may vary if Group 2 data were available may add context to the findings and interpretations of this study. For example, if Group 2 participants displayed no changes in disability at 3 month follow-up, reduction in pain for the entire sample (n=100) would reduce from 74 percent to 54 percent. For present pain intensity, this would reduce from 80 percent to 59 percent. Group 2 data are not available. Findings regarding changes in pain and disability are weakened by the assumption that no changes may have occurred for Group 2. This suggests that findings regarding clinical changes may be overestimated by the present study. These examples indicate that results based on Group 1 data are likely affected by attrition bias.

Therefore, findings from Study 3 may be less generalisable to other CLBP samples than previously believed.

#### 7.4.3.2. Pain and disability and relationships with adherence

Relationships between pain and disability at baseline and adherence at 3 months were compared to relationships between changes in pain and disability over time and adherence at 3 months. Pearson's correlations showed a small, positive, relationship between change in pain and adherence behaviour at 3 months (r=.15; p=.22). Change in pain was not significantly associated with better adherence at 3 months. There was no relationship between change in disability and adherence behaviour at 3 months (r=-.05; p=.68). However, significant relationships were found between baseline pain and disability and adherence behaviour. Pearson's correlations showed a moderate, negative, relationship between baseline pain and adherence behaviour at 3 months (r=-.344; p<.01). There was a moderate, negative, relationship between baseline disability and adherence behaviour at 3 months (r=-.252; p<.05). These results suggest a moderate relationship between lower pain and lower disability at baseline and better adherence at 3 months. Overall, baseline clinical scores were better predictors of adherence behaviour than change scores in the present CLBP sample.

Independent t-tests were used to assess differences in adherence behaviour for individuals with clinically significant changes in disability and the rest of the sample. Effect sizes were small and results were not significant for clinically significant change of 2 points [t(71)=-1.047, p=2.99, *d*=-0.25] or 3 points [t(71)=-.960, p=3.40, *d*=-0.23]. This suggests a weak relationship between disability and adherence to exercise as measured by the EARS.

The impact of attrition may also affect results relating to adherence behaviour data. It is possible that participants who were non-adherent to the present study (Group 2), are less likely to be adherent to prescribed exercise. Although EARS data for Group 2 are not available to confirm this relationship, it is important to consider the possibility that this may be the case. This would suggest that missing data are related to unobserved factors and not accounted for by observed variables, and therefore potentially MAR or MNAR, whereas the above analysis is MCAR. Attrition due to MNAR can lead to underestimated

relationships between variables, which has implications for the relationships between clinical factors and adherence behaviour reported in this section. The correlations do not account for the likelihood of non-completers (Group 2) being less adherent to exercise. This means that strengths of relationships between clinical factors and adherence behaviour may be incorrect if unobserved data from Group 2 are taken into account. For example, the inclusion of non-completers would increase mean baseline pain score for the entire sample, and the small, positive, relationship between change in pain and adherence behaviour at 3 months, would likely display a weaker relationship. In relation to moderate, negative relationships between baseline disability and pain and adherence at 3 months, it would be expected that this would display an even stronger relationship. This indicates that if data are MNAR, bias may be introduced, thus changing the findings of the present study. Problems of missing data are acknowledged in relation to inferences that are made from the present research. The impact of missing data on the findings of Study 3 is further discussed later in this chapter (Section 7.5.4.).

### 7.4.4. Further analysis of exercise adherence data

Study 3 attempted to triangulate measurement of adherence behaviour in order to increase the reliability of results compared with using a single method of measurement (Tenenbaum & Eklund, 2012; World Health Organisation, 2003). This section discusses triangulated adherence behaviour data (7.4.4.1.). Discussion then focuses on a post-hoc analysis of explanations for adherence behaviour provided from 10 'reasons' items ('what helps or hinders doing your exercises?') and an open-ended question ('in your own words, please can you explain why you have, or have not, done your exercises?') (7.4.4.2.). Findings are discussed in relation to correlational analysis between the 10 'reasons' items and psychosocial, clinical and executive functions factors. The last section summarises explanations for exercise adherence behaviour in the present CLBP sample (7.4.4.3.).

#### 7.4.4.1. Triangulated adherence data

In order to triangulate adherence assessment for Study 3, two further assessments of adherence behaviour were obtained in addition to 6-item EARS data. Self-report exercise adherence data were collected regarding number of days per week a participant was asked to exercise compared to the number of days per week they were actually exercising. Participants were asked 'how often have you been asked to do these exercises and/or activities?' (Question 1) and 'for how long have you been asked to continue doing these exercises and/or activities?' (Question 2). Physiotherapists were asked to provide data on exercise adherence behaviour of their patients using the SIRAS. In the SIRAS, physiotherapists scored patients from 1 to 5 based on whether they believed that exercise advice had been followed outside of their treatment sessions (1 = never to 5 = always). However, for reasons further discussed in the main discussion of this thesis (Chapter 8), this information was only obtained for six participants. Table 24 displays triangulated adherence behaviour data for the six participants.

**Table 24.** ***Triangulation of exercise adherence behaviour data***

| Participant number | Question 1 | Question 2 | SIRAS score (1-5) | EARS score (0-24) |
|---|---|---|---|---|
| 3 | Every day | 2-3 days a week | 3 | 6 |
| 9 | 4-5 days a week | 2-3 days a week | 5 | 16 |
| 11 | 4-6 days a week | 4-6 days a week | 5 | 17 |
| 26 | 2-3 days a week | 1-2 days a week | 3 | 13 |
| 33 | Every day | Every day | 5 | 24 |
| 44 | 4-6 days a week | 4-6 days a week | 5 | 22 |

*Note:* Question 1. How often have you been asked to do these exercises and/or activities? Question 2. For how long have you been asked to continue doing these exercises and/or activities?

Table 24 shows that for two participants (P33 and P44), a higher level of adherence to exercise was agreed by the participant (question 2), the physiotherapist (SIRAS) and by total EARS score. In the case of two participants (P3 and P26), a lower level of adherence to exercise was agreed by the participant (question 2), the SIRAS and by total EARS score. Findings from these four participants provide tentative support suggesting that the three measures of adherence behaviour may possibly assess the same construct. However, for one participant (P9), participant ratings of adherence were in agreement (i.e. question 2 and total EARS score). However, the SIRAS rating suggests that this participant always followed exercise advice outside of their treatment sessions. One participant (P3) had a particularly low total EARS score (6). Although, this participant stated that they followed advice to exercise daily for 2-3 days a week. Evidently, more data would be required to surmise

conclusively regarding the ability of each measure to assess the same construct (i.e. exercise adherence behaviour in CLBP).

#### 7.4.4.2. Explanations for exercise adherence behaviour

his section presents a brief post-hoc analysis of explanations of adherence behaviour provided by the CLBP sample in Study 3. Firstly, explanations are presented from the 10 ‘reasons’ items relating to exercise adherence behaviour (7.4.4.2.1.). A content analysis of data from the open-ended question is presented next to provide qualitative information regarding explanations for adherence behaviour in the present study (7.4.4.2.2.).

##### 7.4.4.2.1. Reasons for adherence behaviour based on the 10 ‘reasons’ items

Participants were asked to complete 10 ‘reasons’ items relating to their exercise adherence behaviour (Appendix 4c). Table 25 displays mean scores for the 10 items relating to reasons for non-adherence. Scores for each ‘reasons’ item ranges from 0 (completely agree) to 4 (completely disagree). Items 4, 5, 6 and 7 require reverse scoring so that a higher score indicates better adherence. Pearson product-moment correlation coefficients were used to investigate relationships between the 10 ‘reasons’ items and adherence behaviour (total EARS score). In addition to this, scores for the 10 ‘reasons’ items were correlated with total scores of psychosocial, clinical and executive function factors. The variable that was correlated most highly with each ‘reasons’ item is stated in Table 25.

**Table 25.** ***Means and correlations for 10-items relating to reasons for adherence behaviour***

| 10-Items relating to reasons for adherence behaviour | Mean 'reasons' score (0-4) | Correlation with total EARS score | Psychosocial, clinical or executive function factor and correlation | |
|---|---|---|---|---|
| 1. I don't have time to exercise | 2.6 | .724** | HADS distress | -.338** |
| 2. Other commitments prevent me from doing my exercises | 2.1 | .590** | HADS distress | -.341** |
| 3. I don't do my exercises when I'm tired | 1.6 | .593** | HADS distress | -.326** |
| 4. I feel confident about doing my exercises | 2.7 | -.505** | Zoo Map Test | .349** |
| 5. My family and friends encourage me to do my exercises | 2.7 | -.074 | FABQ Exercise | .201 |
| 6. I do my exercises to improve my health | 2.5 | -.447** | Brief IPQ | -.258* |
| 7. I do my exercises because I enjoy them | 2.0 | -.493** | Brief IPQ | -.211 |
| 8. I adjust the way I do my exercises to suit myself | 1.7 | .165 | RMDQ Disability | -.362** |
| 9. I stop exercising when my pain is worse | 1.5 | .584* | SF-MPQ present pain | .347** |
| 10. I'm not sure how to do my exercises | 2.9 | .550** | BW digit span | .245* |

*Note.* *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed). ES = effect size.

Table 25 shows that lack of time has the strongest relationship with non-adherence (total EARS score). This is closely followed by tiredness, other commitments, pain, not being sure how to do prescribed exercises and adjusting exercises as explanations for non-adherence to prescribed home exercise. Whereas, confidence about performing prescribed exercise displays the strongest relationship with better adherence behaviour. This is followed by enjoyment, health and support from family and friends as explanations of adherence behaviour. These relationships suggest that lack of time would be a primary candidate for discussion in a physiotherapy treatment session. Furthermore, helping the patient to become confident in performing their home exercises appears most likely to aid better adherence compared to other indicators provided by the 10 ‘reasons’ items.

Participants from the present sample were more likely to adhere to prescribed home exercise due to confidence in performing their exercises, to improve their health and due to enjoyment of exercise. Participants were less likely to adhere due to lack of time, tiredness, other commitments and pain. This is useful additional information regarding explanations of exercise adherence behaviour. The factor with the strongest relationship with each ‘reasons’ item can be seen in Table 25. This provides additional useful data regarding potentially modifiable factors that may influence changes in adherence behaviour. For example, lower scores regarding lack of time to exercise, other commitments and tiredness (i.e. a higher agreement with the statements) display moderate, negative relationships with HADS distress score.

Correlations between the 10 ‘reasons’ items and psychosocial, clinical and executive functions factors suggest that better planning ability (the Zoo Map test) plays a role in confidence performing exercises. In addition to this, those with higher self-reported disability (RMDQ) were more likely to adjust exercises to suit themselves. Those with higher present pain (SF-MPQ) at baseline appear to continue exercising when their pain is worse. Additionally, poor working memory (BW digit span) is associated with not being sure how to do prescribed exercise. Relationships between factors assessed in Study 3 and reasons for adherence behaviour suggest that different factors play a role in explaining adherence behaviour in the present CLBP sample. Predictors of adherence behaviour in Study 3 were non-modifiable clinical and demographic

factors. However, findings in Table 25 suggest that potentially modifiable factors also play a role in influencing exercise adherence behaviour in the present CLBP sample.

#### 7.4.4.2.2. Qualitative adherence behaviour data from open-ended question

This section discusses qualitative data from an open-ended question participants were asked prior to completing the EARS questionnaire. This item was ‘In your own words, please can you explain why you have, or have not, done your exercises?” Qualitative data from the open-ended item can be found in Appendix 20. Thirty-eight out of the 74 participants in the present study chose to answer this question. Data were transcribed and content analysis was used to analyse the data (Table 26). Firstly, the researcher became familiarised with the data by reading it multiple times. Secondly, 15 preliminary codes were generated based on recurring patterns within the data (e.g. exercising to strengthen the back or exercising because back health is a priority). Thirdly, the 15 preliminary codes were grouped under six higher-order codes. The six higher-order codes were: a) exercising to improve health and function (H&F), b) exercising to reduce the impact of CLBP (Imp.), c) practical barriers to non-adherence (Prac.), d) physical and mental barriers to non-adherence (P&M), e) barriers directly related to exercise (Exer.) and f) social support (SS). Fourthly, all codes were reviewed by an independent researcher. Lastly, codes were finalised into two meaningful groups using two overarching codes (adherence and non-adherence) to help explain the data in relation to adherence behaviours. Content analysis resulted in six codes incorporating 15 explanations for exercise adherence behaviour for the thirty-eight participants. Table 26 displays an example of a quote for each of the 15 explanations alongside the related code and number of participants using each explanation.

**Table 26.** ***Qualitative data explaining reasons for adherence and non-adherence***

| Explanations of Exercise Adherence Behaviour | Example quote | Number of participants |
|---|---|---|
| **Adherence** | | |
| To reduce pain (Imp.) | 'I do my back exercises to see if my back pain will ease' (P8) | 8 |
| To reduce disability (Imp.) | 'It improves my back a small amount so I am able to get out of bed' (P44) | 2 |
| To strengthen the back (Imp.) | 'I believe that when the muscles in the back are strengthened the pain will go away' (P57) | 2 |
| Back health is a priority (H&F) | 'I got pain now but I will never give up to getting better. My back is priority of my life' (P24) | 1 |
| Support from family (SS) | 'I do my exercises and get my grandchildren to join in with me' (P26) | 1 |
| Happiness/enjoyment (H&F) | ''I do my exercises at home because it makes me more active, happy and less pain on back and joints' (P26) | 1 |
| **Non-adherence** | | |
| Lack of time (Prac. | 'Time. I'm very busy due to full time work and looking after kids' (P49) | 6 |
| Pain (P&M) | 'The only time I don't do exercises is when pain is really bad' (P14) | 5 |
| Other commitments (Prac.) | 'My family commitments sometimes prevent me from completing the exercises' (P70) | 3 |
| Too tired to exercise (P&M) | 'If I have to go out for the day and come back tired then can't do them' (P96) | 2 |
| Forget to exercise (P&M) | 'Sometimes I forget' (P77) | 2 |
| Lack of motivation (Exer.) | 'Not particularly well motivated' (P27) | 2 |
| Exercise is boring (Exer.) | 'It's boring' (P58) | 1 |
| Exercise is a waste of time (Exer.) | It's a waste of time really, I feel like I am rushing around and still in pain' (P92) | 1 |
| No space to exercise (Prac.) | 'I don't have the space where I live with my flatmates' (P91) | 1 |

Table 26 shows that the most frequently cited explanation for better exercise adherence behaviour was exercising to reduce pain (8 participants). This was followed by reducing disability (2 participants) and strengthening the back (2 participants). The most frequently cited explanation for non-adherence to prescribed exercise was lack of time (6 participants) and pain (5 participants). This was followed by other commitments (3 participants) and lack of motivation, tiredness and forgetting to exercise (cited by 2 participants).

Certain explanations cited by participants when answering the open-ended question were not included in the 10 'reasons' items. For example, the entire theme 'barriers directly related to exercise' (Exer.) was not accounted for in the 10 'reasons' items. One reason for this may be because participants of the focus group may not have wanted to state negative opinions regarding exercise with a physiotherapist and researchers present. However, this would have been less of an issue when completing a self-report question. Lack of time was one explanation of adherence behaviour that showed the strongest relationship with adherence behaviour in Table 26 and was cited most by participants answering the open-ended question. This suggests that time constraints play a large role in whether or not an individual with CLBP adheres to prescribed home exercise advice.

#### 7.4.4.3. Summary of further analysis of exercise adherence behaviour

This section described data provided from triangulated exercise adherence data and data regarding explanations for adherence behaviour in the CLBP sample. Overall, the three different assessments of adherence behaviour (i.e. total EARS score, numbers of days per week exercising and SIRAS score) appear to be in agreement with each other. However, data were only obtained from six participants. Additional data would be required to reach clearer conclusions regarding exercise adherence behaviour from the three measures of adherence behaviour used in Study 3. With regards to explanations for adherence behaviour based on the 10 'reasons' items, participants in the present CLBP sample were less likely to adhere to prescribed home exercise due to lack of

time, tiredness, other commitments and pain. However, they were more likely to adhere due to confidence in performing their exercises, to improve their health and due to enjoyment of exercise.

Correlations between the 10 ‘reasons’ items and psychosocial, clinical and executive functions factors also suggest that distress played the largest role in explaining non-adherence to exercise. Furthermore, planning ability, disability, present pain, illness perceptions and working memory all played a role in explaining exercise adherence behaviour in the CLBP sample. Factors such as distress and illness perceptions are psychosocial factors that are more modifiable than factors found to predict adherence behaviour in Study 3 (i.e. demographic and clinical factors). This suggests that intervention may focus on associated, but modifiable, factors that have been shown to influence exercise adherence behaviour in the present research.

Fifteen explanations of adherence behaviour were identified from answers to the open-ended question. Reduction in pain was the most frequent explanation for adhering to prescribed exercise advice. In contrast, lack of time was the most frequent explanation for non-adherence behaviour. Furthermore, time constraints appeared to play a large role overall in explaining why individuals with CLBP may be non-adherent to prescribed home exercise advice. However, it is important to note that answers to the open-ended question were not analysed in-depth. This is because the data were analysed post-hoc and time constraints did not allow for more detailed analysis. Therefore, the findings presented in the current section should be interpreted cautiously as common themes may differ if data were analysed using more detailed qualitative data techniques.

## 7.5. Discussion

Discussion of the present research is presented in six sections. Main findings from Study 3 are summarised (7.5.1.). Baseline findings were discussed in the previous chapter (Chapter 6). Therefore, this section focuses on follow-up findings regarding predictors of exercise adherence behaviour in relation to

extant research (7.5.2). Subsequent to this, the importance of acknowledging executive function deficits in the treatment of CLBP are discussed (7.5.3.). The remaining discussion brings together baseline and follow-up findings in relation to methodological considerations, clinical and research implications and conclusions of the study. Methodological considerations are discussed in relation to how these affect inferences from the results of the study (7.5.4). Subsequent to this, discussion focuses on clinical and research implications of the research (7.5.5.). Last, conclusions of the findings of Study 3 are presented (7.6.).

### 7.5.1. Summary of main baseline and follow-up findings

Baseline findings from Study 3 showed that the CLBP sample displayed lower than normative scores on executive function tasks assessing planning ability and behavioural inhibition. However, scores were within normative ranges for tasks assessing working memory and pre-morbid IQ (Research Objective 3). A hypothesis of Study 3 was that executive functions would predict additional variance in exercise adherence behaviour over and above that which was explained by psychosocial and clinical variables. This hypothesis was not supported as significance testing failed to find sufficient evidence to reject the null hypothesis and ES was small. Follow-up investigations involved assessment of executive function, psychosocial and clinical factors in relation to adherence to prescribed home exercise in CLBP (Research Objective 4). The four factors that were found to play a predictive role in adherence behaviour were longer duration of pain, higher present pain, lower educational level and being female. Executive function and psychosocial factors were not predictive of adherence behaviour. Assessment of relationships between clinical factors and adherence behaviour found moderate relationships between lower pain and disability at baseline and better adherence at 3 month follow-up (Research Objective 5).

### 7.5.2. Predictors of exercise adherence behaviour and existing research

The fifth research objective was an extension of the fourth research objective. Therefore, it seems logical to discuss the results of these research objectives together. Results regarding demographic predictors of adherence behaviour are briefly explored (7.5.2.1.). The role of clinical variables in predicting adherence behaviour is discussed in relation to the systematic review conducted in Study 1 (Chapter 3) (7.5.2.2.).

#### 7.5.2.1. Demographic factors and exercise adherence behaviour

Demographic factors that predicted non-adherence to prescribed home exercise in CLBP were lower educational level and being female. Demographic factors have rarely been investigated in relation to exercise adherence behaviour in CLBP or MSK conditions. However, existing CLBP research supports the findings of Study 3 that being female predicts non-adherence to prescribed home exercise (e.g. Mannion et al., 2009; Hügli et al., 2015). Furthermore, gender has been found to predict exercise adherence behaviour in a mixed chronic neck pain and CLBP sample (Engström & Öberg, 2005). Mannion and colleagues (2009) found that women were significantly less adherent than men on all three measures of adherence behaviour used in their study (i.e. appointment attendance, percentage of home exercises completed and in-clinic adherence behaviour). However, a study investigating a mixed MSK sample found no gender differences in exercise adherence behaviour (Sluijs, Kok, & van der Zee, 1993). Furthermore, a previous study found no evidence for the role of gender in a mixed low back pain (LBP) sample when using the same three assessments of adherence behaviour as Mannion and colleagues (2009; Kolt & McEvoy, 2003).

Hügli and colleagues (2015) contributed further to the findings of the present research and previous CLBP and MSK research by finding that women displayed better adherence than men for prescribed home exercise that included an augmented feedback component. However, women adhered less

than men for conventional physiotherapy prescribed home exercises. These findings suggest that type of prescribed home exercise may play a moderating role in the relationship between gender and exercise adherence behaviour in CLBP. This is discussed further in the main discussion of this thesis in relation to learnings from research investigating exercise behaviour in healthy samples.

It is difficult to surmise conclusively from the paucity of evidence regarding the role of gender in adherence to prescribed home exercise. However, a key problem when comparing findings across studies is lack of standardised assessment of adherence behaviour. This results in difficulties clarifying exactly where the effect of gender plays a role in adherence behaviour. For example, Mannion and colleagues (2009) defined adherence to prescribed home exercise by percentage of completed home exercises from an exercise diary. Whereas, the present research used a structured questionnaire to assess adherence (i.e. the EARS) and Sluijs and colleagues (1993) calculated a percentage based on a single question (‘did you manage to exercise regularly last week?’). These examples demonstrate the extensive variation in measurement of exercise adherence behaviour that is discussed further later in this chapter.

The few CLBP studies that have assessed demographic factors in relation to exercise adherence behaviour have not investigated level of education. However, level of education has been investigated in a mixed MSK sample (25% LBP) where more highly educated patients were less adherent to prescribed home exercise than those with lower education levels (Sluijs et al., 1993). These findings are contrary to findings from the present study. However, findings from Sluijs and colleagues (1993) research are more difficult to generalise to CLBP as 50 percent of the sample included a variety of ailments (e.g. trauma and post-operative conditions and multiple pathologies). It is likely that barriers to exercise adherence post-surgery may bear some relation to immediate side-effects from the surgery itself (e.g. Chan, Lonsdale, Ho, Yung, & Chan, 2009). Therefore, post-surgical barriers likely differ from barriers to exercise adherence in a non-specific CLBP sample. Furthermore, a large proportion of the sample (25%) were labelled as ‘other’. Therefore, no comment

can be made regarding the representativeness of findings regarding adherence behaviour to a CLBP sample. Heterogeneity in assessment of exercise adherence behaviour remains a problem that leads to difficulties when comparing research findings between studies.

Findings from CLBP and MSK research literature suggest that gender, education level and type of prescribed home exercise should be considered in the treatment of women with CLBP. Women in England have been found to exercise less than men in general. For example, a 2011 survey found that 40% of men and 28% of women state that they follow Chief Medical Officer guidelines to do moderate exercise for 2.5 hours per week (Department of Health, 2011). Therefore, it is expected that these gender differences may persist to a certain degree in chronic illness conditions. Mannion and colleagues (2009) and Engström and Öberg (2005) both interpret gender differences in adherence behaviour in light of social constructions of gendered health and state that women are less adherent as they are more likely to prioritise significant others before themselves (e.g. in terms of time, money and health) (Riska, 1997; Hammarström, Härenstam, & Östlin, 2001). In-depth qualitative research may refute or confirm social constructionist theories. For example, based on Hügli and colleagues' (2015) findings, women with CLBP who prioritise their children over following prescribed exercise advice, may find certain types of exercise more acceptable than others. Further research should consider that the assessment of education level is likely to be influenced by related factors such as intelligence, social class and health literacy (Roberts, Cavill, Hancock, & Rutter, 2013). Therefore socio-demographic assessment should consist of numerous variables to provide comprehensive evaluation of which areas predict unique variance in exercise adherence behaviour. Clearly, more research is required to provide a clearer understanding of the impact of education level and gender on adherence to prescribed home exercise in CLBP. Demographic factors are explored further in relation to exercise adherence behaviour in healthy samples and in medication adherence literature in the main discussion of this thesis (Chapter 8).

#### 7.5.2.2. Clinical factors and exercise adherence behaviour

Clinical factors that were found to play a role in predicting non-adherence to prescribed exercise were longer duration of pain and higher present pain. This was supported by findings of moderate effects between lower baseline present pain and pain intensity and better adherence at 3 months. Of the four factors that predicted adherence in the present study, only level of pain has been associated with adherence to home exercise in CLBP.

Extant CLBP research does not concord with the findings of the present study that higher levels of pain predict non-adherence to prescribed home exercise. One study included in the systematic review found that higher pain was associated with better adherence to exercise (Donzelli et al., 2006). Clinical factors have not been investigated in relation to home exercise in other CLBP samples, however related evidence from a study assessing adherence to exercise in a mixed MSK sample also oppose the findings of the present research. For example, Sluijs and colleagues (1993) found that higher pain was associated with better compliance in a mixed MSK sample (27% LBP).

One explanation for the finding that higher pain leads to better adherence in the aforementioned studies may be because these studies included interventions to improve adherence to prescribed exercise, whereas the present study assessed adherence to standard, conventional physiotherapy treatment with no intervention attempting to improve adherence behaviour. Treatment in Donzelli and colleagues' (2006) study included supervision that was additional to standard physiotherapy treatment. Some discomfort is common when starting a new exercise regime and reassurance through supervision is likely to play a role in motivating the patient to continue exercising (if appropriate) when pain increases (Cohen & Rainville, 2002; Sluijs et al., 1993). This notion has been substantiated by further studies that have found supervision to increase adherence to exercise in CLBP (Liddle et al., 2004; Ljunggren et al., 1997; Reilly et al., 1989). However, research is needed to explore the effects of

different types of supervision (for example, individual or group supervision) and how these influence long-term adherence to home exercise in CLBP.

Another explanation for conflicting results may be due to weaknesses of the present study. For example, missing data were not MCAR, thus potentially introducing biases that may have affected strength and direction of findings. Furthermore, neither the present research nor the opposing studies included long-term follow-up, therefore it is difficult to assess whether adherence patterns for people with higher pain levels may change over time and how this may affect CLBP and its treatment in the long-term. Moreover, there are issues of generalisability from findings from the present CLBP sample. Problems of generalisability are discussed further later in this section.

### 7.5.3. Acknowledging executive function deficits in the treatment of CLBP

Executive function variables were not found to predict adherence behaviour in Study 3. These findings may due to the fact that the executive functions assessed are not related to adherence behaviour. Alternatively, findings may be due to limitations of the present research (e.g. sample size and measurement of adherence behaviour). Conventional physiotherapy treatments are seldom effective at improving CLBP in the long-term (Traeger et al., 2014). Therefore, the presence of executive function deficits in a CLBP sample remains an important research and clinical consideration.

Two pioneering studies (i.e. Shpaner et al., 2014; Seminowicz et al., 2011) have demonstrated improvements in executive function deficits that have been associated with improved clinical outcome in CLBP. These studies do not investigate exercise adherence behaviour. However, they do demonstrate the relevance of executive functions in the treatment of CLBP. Seminowicz and colleagues (2011) found that treatment of CLBP with spinal surgery or facet joint injections led to normalisation of previous brain changes. Both treatments also had a positive effect on post-treatment performance of executive function tasks. Furthermore, and particularly relevant to the treatment of CLBP,

reductions were found in self-reported pain (44% reduction) and disability (46% reduction) at 6 month follow-up. These findings suggest that spinal surgery and facet join injections may be able to alleviate the impact of CLBP in the short-term.

Spinal surgery and facet joint injection treatments are invasive and costly methods of treating CLBP and are unlikely to be appropriate for the majority of CLBP patients (Jackson & Simpson, 2006). Previous CLBP research has suggested that facet joint injections are ineffective in the both the short and the long-term (e.g. van Tulder, Koes, Seitsalo, & Malmivaara, 2006). However, pain relief from facet joint injections may provide opportunity for more rigorous exercise treatment (Tibrewal, Khan, & Tibrewal, 2007). Furthermore, according to the findings of Study 3, individuals with CLBP may be more likely to adhere to prescribed home exercises when pain levels are reduced. Long-term follow-up of Seminowicz and colleagues' (2011) study is necessary to understand the function and impact of these treatments on CLBP in the long-term.

A recent study by Shpaner and colleagues (2014) found that learning new pain management methods as part of a cognitive behaviour therapy (CBT) programme, improved previous functional brain changes in a mixed chronic MSK pain sample, including CLBP (exact percentage of CLP patients not stated). Improvements were also found in pain, depression and anxiety in the short-term (3 months). Improvements in self-reported disability were not significant. This suggests that CBT may be effective at reducing certain key outcomes that have been shown to maintain CLBP (e.g. anxiety and depression; Pincus & McCracken, 2013). However, evidence that relationships between pain and executive function deficits vary across chronic pain samples (e.g. Apkarian et al., 2004) suggest that findings cannot be easily generalised to CLBP. Furthermore, longitudinal research is required to demonstrate whether CBT is effective at improving functional changes in the brains of individuals with chronic pain in the long-term.

### 7.5.4. Methodological considerations

The present study provides novel findings in an under-researched area that may help to inform future research and treatments for individuals with CLBP. It was the first study to assess the role of executive functions in adherence to prescribed home exercise in a chronic illness sample. However, executive functions were not found to be predictive of adherence behaviour. Reasons for this may be due to limitations of the present study, which are discussed in relation to sample size (7.5.4.1.), age restriction (7.5.4.2.), attrition and missing data (7.5.4.3.), problems with assessment of adherence behaviour (7.5.4.4.) and executive functions (7.5.4.5.), length of follow-up (7.5.4.6.) and issues relating to simultaneous testing of hypotheses (7.5.4.7.).

#### 7.5.4.1. Sample size

The smaller than expected final sample meant a reduction in statistical power, and the 26 percent attrition rate at 3 month follow-up reduced statistical power further. This may lead to a reduction in the precision of parameter estimates and predicted values for the results of the multiple regressions. Therefore, it was understood that a statistically significant effect would be difficult to detect, even if one existed. Measures to reduce independent variables for entry into the regression models were not taken due to the decision that amendments to established statistical criteria would result in less comparable results between the two hierarchical regression models. Similarities between R squared values for the regression models indicated that the models did not appear to be modelling excess random noise due to the inclusion of a larger number of independent variables. Therefore, results are interpreted with the knowledge that the diminished sample size likely leads to a reduction in detectable ES, increasing the risk of failing to reject a false null hypothesis (a Type 2 error). As a result of this, results relating to predictors of adherence behaviour are only cautiously generalised to other CLBP samples.

#### 7.5.4.2. Age restriction

Age range was restricted in Study 3 in order to control for potential confounding factors that might otherwise bias the results of the study (i.e. age-related cognitive decline and age-related co-morbid illness). Choosing to restrict age due to increased risk of co-morbidity seemed logical due to difficulties controlling for multiple factors that could influence adherence behaviour (see Chapter 5, Section 5.3.2.). With regards to restricting age due to age-related cognitive decline, researchers previously believed that a significant decline in executive functions did not occur until approximately the age of 65 (e.g. Finkel & Pederson, 2010). However, this premise is not supported by a recent review that found that cognitive decline may begin as early as 20 years of age (Salthouse, 2012). Furthermore, although executive functions in general have been thought to decline at a similar rate, they have recently been found to decline at different rates depending on the individual (Kievit et al., 2014). Restricting age to reduce problems related to cognitive decline is not supported by the aforementioned research and, in hindsight, the restriction may not have been necessary when age could have been controlled for statistically.

Executive functions were not predictive of adherence behaviour in Study 3. One reason for this may be because the age restriction minimised the chances of finding an executive function effect on adherence behaviour. The reason for this is that an older sample is likely to include more people with lower levels of executive function, which, in turn, may have influenced levels of adherence behaviour. Study 3 found that people with CLBP aged 18 to 65 displayed lower than normative scores on executive function tasks assessing planning ability and behavioural inhibition. There are multiple reasons that could explain poor performance on the executive function tasks (e.g. psychometric problems related to the tasks, testing conditions, task burden, participant fatigue and pain – see Chapter 2, Sections 2.2. and 2.3.). However, certain factors (e.g. confounding factors related to undiagnosed co-morbid chronic illness) are less likely to have impacted the results due to the fact that no participants over 65 were included in the study. The clinical implications of this are that

physiotherapists would have to be aware of the age limit set by this research and use the information accordingly in practice. For example, a physiotherapist may wish to consider whether a patient aged 18-65 with CLBP might have difficulties planning and inhibiting in their daily life. These difficulties might influence aspects of physiotherapy treatment (e.g. attending weekly back class appointments) and their chronic condition, even though they did not predict adherence behaviour in the present research.

#### 7.5.4.3. Attrition and missing data

Problems of missing data introduced biases that were considered in relation to inferences from findings relating to each type of missing data analysis. The present research assessed missing data using numerous methods including missing value analysis, a MAR sensitivity analysis using MI and comparison of completers and non-completers of the study. Sensitivity analysis using MI suggested that missing data were MAR (i.e. related to observed variables in the dataset). This suggests that the results of the two hierarchical regression models using listwise deletion of data may provide biased parameter estimates, thus caution must be taken when interpreting results of these analyses.

#### 7.5.4.4. Problems with assessment of exercise adherence behaviour

The EARS was used to assess adherence behaviour in the present study. The EARS experiences many of the same issues as any self-report measure, such as memory lapses, social desirability and recall bias. Furthermore, the EARS requires further psychometric evaluation to provide additional information regarding validity and reliability. However, the present study provided further support for the reliability and validity of the EARS. For example, internal consistency ($\alpha = 0.892$) of the EARS was re-evaluated in the present CLBP sample. Furthermore, preliminary convergent validity was evaluated using triangulated measures of adherence. Although, the final sample (n=6) was not large enough to surmise conclusively regarding convergent validity.

No standardised measures were found to assess adherence to prescribed home exercise in CLBP in the present study. Electronic devices were not used as they are not suitable for the assessment of specific prescribed exercises as they primarily measure activities of daily living (e.g. standing, walking or taking the stairs) (Yang and Hsu, 2010). Furthermore, measuring adherence using an electronic device or diary could be classed as an intervention in itself as these have been shown to increase exercise, making it difficult to obtain an accurate baseline measure of adherence (Haynes et al., 2008). The findings of the present research are only as robust as the measures used to assess outcome. However, this was the first study to use a psychometrically evaluated assessment of self-reported adherence behaviour, albeit requiring further evaluation, which is an important step forward from previous exercise adherence research.

#### 7.5.4.5. Problems with assessment of executive functions

Assessment of executive functions is fraught with difficulties (Berryman et al., 2013). Limitations of executive function tasks (e.g. reliability and validity) are described in detail earlier in this thesis (Chapter 2). These limitations lead to difficulties surmising conclusively from the findings of the present research regarding executive functions. Hence, it is difficult to state with certainty that the present CLBP sample have deficits in specific areas of executive function posited to be assessed by executive function tasks used in Study 3.

Several measures are available to assess various domains of executive function, however there is no standard test for any of these domains (Pickens et al., 2010). Assessing executive functions in the present CLBP sample presented the difficulty that a true test of executive function should assess the ability of the individual to perform a task under realistic, but novel, conditions (Berryman et al., 2013). However, testing occurred in a solitary room in a physiotherapy department in a hospital, which is the antithesis of this notion. In an attempt to reduce the impact of this problem, the Zoo Map test was selected

to assess planning ability in the present study due to claims that it assesses planning in a complex, real-life situation (Wilson et al., 1997).

The Zoo Map test, the WTAR and the backwards digit span test are all posited to assess a main domain of executive functions (i.e. planning ability, pre-morbid IQ and working memory), but evidence suggests that overlapping constructs are likely also assessed to some extent for all executive function tests. This premise is supported by research that has found executive functions to be both separable, but also related, in terms of sharing a similar underlying commonality (Hull et al., 2008; Miyake et al., 2000).

The Stroop test in particular displays problems of internal validity. For example, it has been used to assess inhibition (Wilkinson & Yang, 2015; Troyer et al., 2006), behavioural inhibition (Cisler et al., 2009; Field & Franken, 2014), set-shifting (also known as task switching) (Stemme et al., 2007), cognitive flexibility (Uttl & Graf, 1997), interference (Stroop, 1935; Kravariti et al., 2009) and general executive functioning (Moering et al., 2004; Zalonis et al., 2009). Due to resulting problems of interpretation, attempts are made to interpret findings in a logical way that relates to a specific research field. For example, in the case of the present study, behavioural inhibition and planning ability are proposed to be most relevant to adherence to prescribed home exercise, although it is likely that other domains of executive function may also play a role.

Further problems that are specific to the Stroop test include variations in the number of sub-tests, the colours, number of words tested and the procedure and administration of the test (Pilli, Naidu, Pingali, Shobha, & Reddy, 2013). This lack of standardisation is common in executive function tests and lead to difficulties isolating the key processes that may affect the sample. Standardisation and psychometric evaluation of executive function tests would help to overcome these problems. This would provide novel information that is specific to individual conditions and may inform future research and clinical practice.

#### 7.5.4.6. Length of follow-up

The follow-up period for the present study was 3 months. Periods of exacerbation and remission are common in CLBP (Medina-Mirapeix, Escolar-Reina, Gascón-Cánovas, Montilla-Herrador, & Collins, 2009). Therefore, more frequent follow-up may provide information more useful to the treatment of CLBP. For example, weekly assessment of disability, pain and adherence may provide more detailed information about clinical factors and their relationships with adherence behaviour. Furthermore, longer-term follow-up may also provide additional useful information about symptoms of CLBP and adherence over time. For example, Marks and Allegrante (2005) found that there were short-term benefits of interventions that aimed to improve adherence to exercise. However, these benefits were no longer apparent when contact with the healthcare provider ended. This indicates that longer-term follow-up may be necessary to better evaluate treatments or interventions that include an adherence component.

#### 7.5.4.7. Simultaneous testing of hypotheses

A further limitation of Study 3 was the simultaneous testing of multiple hypotheses from a single dataset at an alpha level of $p = .05$. Multiple testing can lead to an inflated Type 1 error rate (i.e. incorrect rejection of the null hypothesis) and is referred to as familywise error. Post-hoc tests (e.g. estimation of familywise error rate and the Bonferroni test) can be performed to estimate the probability of making Type 1 errors or to calculate new pairwise alpha levels. However, due to the exploratory nature of this research, it was deemed justifiable to accept an inflated Type 1 error rate. Therefore, no post-analysis adjustments were made. As a result of this, the results of Study 3 should be interpreted with caution as significant results may be incorrect due to the inflated Type 1 error rate. Any significant findings would need replication with the parameter estimates used to inform the sample size of an appropriately powered study with adequate control for Type 1 errors.

### 7.5.5. Clinical and research implications

The results of this study suggest that physiotherapists should consider demographic factors (i.e. level of education and gender) and clinical factors (i.e. duration of pain and level of pain) when collaborating with patients to design treatment plans that require adherence to prescribed home exercise. However, unlike potentially modifiable factors that have been associated with adherence to exercise in mixed-MSK samples (e.g. mood - Jack et al., 2010), demographic and clinical factors are less modifiable. For this reason, psychological treatments such as CBT, that focus on modifying unhelpful beliefs, could be deemed as relatively ineffective to improve adherence to prescribed home exercise in CLBP. This seems logical in relation to level of education. However, if reasons why women are less adherent to exercise advice are based on social constructionist views as suggested by certain research (e.g. Engström & Öberg, 2005), attempting to modify beliefs surrounding these views may help to change the way women view their priorities and thus, influence resulting exercise adherence behaviour.

CBT is often used as part of a multi-disciplinary programme to treat CLBP (Gatchel & Rollings, 2008). CBT is used as an indirect method of improving clinical outcome in CLBP. For example, modifying maladaptive beliefs about pain may reduce overall distress, resulting in a reduction in pain (Turk, 2003). Treatment of CLBP using a combined physical therapy and CBT approach has led to improved short-term reduction in disability (Hill et al., 2010). However, reductions in disability were not significant at 12 months. Recent chronic pain research suggests that a key reason for this may be because the effectiveness of cognitive-behavioural treatments has reached a plateau (Eccleston et al., 2013; see Chapter 1, Section 1.1.4.2.). Furthermore, it has been suggested that new information regarding factors influencing the maintenance of CLBP is needed to enable more effective long-term treatment (Farmer et al., 2012). Recent research has found that CBT incorporating pain management techniques reversed neurological impairments found in a mixed chronic pain sample (including CLBP) (Shpaner et al., 2014). These findings suggest that

CBT may well be able to modify clinical factors that have been shown to predict adherence behaviour in the present study. CBT is discussed further in the main discussion of this thesis in relation to the findings of the present research.

CLBP is an under-researched area where some information is known about the nature of executive function deficits, but very little is known about their impact on the treatment and maintenance of CLBP. Deficits were found in the present CLBP sample but these did not predict adherence to prescribed home exercise as assessed by the EARS. However, the EARS requires further psychometric testing before inferences can be made regarding its ability to validly and reliably assess adherence to prescribed home exercise. Until then, the fact that executive function deficits have consistently been found in individuals with CLBP, suggests that these factors should not be ignored in the treatment of CLBP. One reason for this may be because certain executive function deficits (e.g. poor planning ability and high behavioural inhibition) influence aspects of treatment, other than adherence to home exercise that may otherwise improve outcome in CLBP. For example, higher anxiety and depression are associated with poorer executive functions (e.g. Grachev et al., 2003) and also with increased disability in CLBP (Smeets et al., 2006). Anxiety and depression have been associated with non-adherence to exercise in mixed MSK samples (e.g. Jack et al., 2010). Furthermore, it seems logical that improvement in executive functions may allow for the more effective use of self-regulatory process to aid coping mechanisms that may reduce high anxiety and depression (Nes et al., 2009). This may be one of numerous indirect influences of executive functions that require investigation to evaluate their impact of on specific areas of treatment and outcome in CLBP.

Executive functions are a relatively recent area of study in CLBP (Wand et al., 2011). Until further research investigates how executive functions may be improved in individuals with CLBP, clinicians should consider known factors that may influence deficits in executive functions and treatment outcome (e.g. sleep and stress) (Hall & Fong, 2015). However, making these suggested changes may be problematic for individuals with executive function deficits and

perpetuate a negative cycle where deficits continue to worsen over time. An updated model of temporal self-regulation theory (TST) posits that changes in exercise behaviour require better executive functions initially in order for individuals to gain access to a positive feedback loop where adherence to behaviour change will lead to improved executive control (Hall & Fong, 2015). Subsequent investigations should examine suitable methods of improving executive function that can be effectively used within physiotherapy consultations.

Simple tasks requiring self-regulation may be one method of improving self-regulatory capacity and related executive functions (Hagger et al., 2010). Frequent engagement in simple tasks requiring self-regulation has been found to improve self-regulatory abilities (Hagger et al., 2010). Examples of simple self-regulatory tasks that may be incorporated into daily life include use of the non-dominant hand to perform tasks around the house, modifying poor posture and monitoring diet, all of which have been found to increase adherence to exercise in healthy samples (Gailliot, Plant, Butz, & Baumeister, 2007; Hagger et al., 2010). Hagger and colleagues (2010) suggest that training on one type of task will lead to improved self-regulation when engaging in other tasks. This implies that individuals could potentially choose from a number of tasks requiring self-regulation that could be modified on a daily basis to suit their requirements. Future research should examine further types of self-regulatory tasks that improve self-regulatory capacity, and confirm exactly what the benefits may be in relation to outcome for CLBP. This, in turn, may inform clinicians and researchers of benefits that are directly related to improvements in executive function so that these factors this can be monitored and evaluated as part of on-going treatment.

### 7.6. Conclusions

The main objective of this study was to assess the role of executive functions, demographic and clinical factors in relation to adherence to prescribed home exercises in a CLBP sample. The EARS was developed to assess exercise

adherence in this study. However, the EARS is still in preliminary stages of psychometric evaluation. Therefore, results relating to adherence behaviour as assessed by the EARS should be interpreted with caution until further reliability and validity testing determines the robustness of the measure. Nonetheless, preliminary psychometric evaluation of the EARS lends credibility to the findings of the present study.

Executive function factors were not found to predict adherence behaviour in Study 3. However, demographic and clinical factors did play a predictive role. The study provided insights into executive function deficits in planning ability and behavioural inhibition in a CLBP sample. However, it is necessary to clarify to what extent CLBP is related to these deficits. Research investigating the use of CBT to modify executive function deficits in chronic MSK conditions may provide novel information to help move the research field closer towards finding non-invasive solutions for the treatment of CLBP. The continued study of psychosocial, clinical and executive function factors associated with back pain may facilitate the development and evaluation of interventions that encourage long-term self-management for both the prevention and treatment of CLBP.

# 8. Discussion

## 8.1. Overview

Chronic low back pain (CLBP) is difficult to treat and 80 percent of people with CLBP are likely to have recurrent symptoms throughout their lives (Waddell & Schoene, 1998). Home exercise programmes are designed to encourage patients to remain active post-treatment and long-term adherence to these programmes is important for patients to maintain lasting benefits (Friedrich et al., 2005). However, between 50 percent (Friedrich et al., 1998) and 70 percent (Harkapaa et al., 1991; Reilly et al., 1989) of individuals with CLBP do not adhere to prescribed home exercises. Few studies have investigated factors that influence adherence to prescribed home exercise in CLBP. Consequently, there is a lack of detailed information that may assist clinical practice in the treatment of CLBP. This thesis has addressed gaps in the CLBP research literature by identifying factors that influence adherence to prescribed home exercise in previous CLBP research (Study 1), developing a measure to assess exercise adherence behaviour in CLBP (Study 2) and investigating factors predicting prescribed home exercise in a CLBP sample (Study 3). This chapter describes the findings of these three studies with reference to the wider evidence base of CLBP and medication adherence research literature and findings from investigations of exercise behaviour in healthy samples.

Firstly, the five research objectives and hypothesis of this thesis are reiterated (8.2.). The next three sections summarise and discuss the findings of the three studies of this thesis in relation to extant research. The systematic review conducted for Study 1 is discussed in relation to CLBP studies that were published after Study 1 (8.3.). The next section focuses on the Exercise Adherence Rating Scale (EARS) that was developed for Study 2 (8.4.). Current issues regarding exercise adherence measurement in CLBP are explored in this section. Subsequently, factors predicting exercise behaviour in CLBP are examined in the of research literature, with a focus on non-modifiable demographic factors (i.e. gender and education) (8.5.). The next section

discusses theoretical implications of the findings of the present research (8.6.). This section described limitations of traditional models of behaviour change in relation to the findings of Study 3. A more comprehensive model of behaviour change is recommended for future research investigating exercise behaviour in CLBP samples. Strengths and weaknesses of the three studies of this thesis are described next (8.7.). Finally, implications for future research and clinical implications are elaborated (8.8.). The last section presents overall conclusions of this thesis investigating adherence to prescribed home exercise in CLBP (8.9).

## 8.2. Research Objectives and Hypothesis of the thesis

**Study 1:**

**Research Objective 1:** To identify the factors which have been found to influence adherence to prescribed home exercise in CLBP in previous research with a systematic review.

**Study 2:**

**Research Objective 2:** To develop a measure to assess adherence to prescribed home exercise.

**Study 3:**

**Research Objective 3:** To assess and examine relationships between psychosocial, clinical and executive function factors in individuals with CLBP.

**Research Objective 4:** To evaluate the possible roles of psychosocial, clinical and executive function factors in adherence to prescribed home exercise in CLBP.

**Research Objective 5:** To determine whether adherence to prescribed home exercise is related to clinical outcome.

**Hypothesis:** Executive functions will predict additional variance in adherence behaviour over and above that which is explained by psychosocial and clinical factors.

### 8.3. Study 1: Results of the systematic review and comparison with recent research

Study 1 identified individual and intervention-related factors associated with adherence to home exercise in CLBP (Beinart et al., 2013). The systematic review found 11 randomised controlled trials (RCTs) that provided moderate evidence that one individual patient sub-factor, and three intervention-related sub-factors, were associated with better adherence behaviour. The individual patient sub-factor was higher health locus of control. The intervention-related sub-factors were: a) supervision, b) participation in an exercise programme, and c) participation in a general behaviour change programme (BCP) incorporating motivational strategies. There was conflicting evidence that level of distress at baseline was associated with adherence behaviour.

Prescribed home exercise is a key component of physiotherapy treatment for CLBP (NICE, 2009). However, Study 1 found that only a small number of factors have been investigated in relation to adherence to prescribed home exercise in previous CLBP research. The original search to identify appropriate articles was conducted on 18th January 2012. Therefore, the same search was performed on 2nd October 2015 to identify recent studies investigating adherence to prescribed home exercise in CLBP. This search resulted in one RCT (Hügli et al., 2015), one protocol for an RCT (Saper et al., 2014) and two online abstracts (Lonsdale et al., 2014; Freson, Henry, Buzzell, & DeSarno, 2012). Although the abstracts would not typically be included in a systematic review, they are discussed here to provide information regarding the state of research literature investigating exercise adherence behaviour in CLBP samples at the current time. The protocol may not provide information regarding factors that influence adherence behaviour. However, it may provide additional information regarding assessment of adherence to prescribed home exercise.

Hügli and colleagues (2012) conducted a pilot RCT comparing adherence to home exercises based on conventional physiotherapy (CP) treatment versus augmented feedback (AF) treatment in CLBP. Participants in the AF group were given a laptop including video games developed to assist with movement control and body stabilisation for the lower back. In addition to this, participants wore two sensors to track their body movements during exercise. Adherence behaviour was assessed using a home exercise diary stating duration of daily exercise in minutes. The Sports Injury Rehabilitation Adherence Scale (SIRAS, Brewer et al., 2000) was used to assess physiotherapist rating of patient adherence. There were no differences of duration of home exercise between the two groups. However, they found that women displayed poorer adherence than men in the CP group. Furthermore, women displayed better adherence than men in the AF group. The role of gender in predicting exercise behaviour in CLBP is further discussed later in this chapter in relation to findings from Study 3.

Home exercise is prescribed as a form of long-term self-management to assist in the reduction clinical symptoms for CLBP (Savigny et al., 2009). However, Hügli and colleagues (2015) only assessed adherence behaviour at the end of nine treatment sessions (exact duration of time not stated). Therefore, it can be argued that their findings provide an unrealistic view of adherence behaviour as adherence to prescribed home exercise is likely to be better during a time of regular supervision (e.g. Ljunggren et al., 1997; Reilly et al., 1989). This leads to difficulties comparing Hügli and colleagues' (2015) findings to studies identified in Study 1 that all included post-treatment assessment of adherence behaviour (from 4 weeks to 5 years). Additionally, a pilot sample of 20 participants is likely to result in inadequate statistical power to detect statistically significant effects. A fully powered RCT would be necessary to provide robust findings regarding gender and type of exercise in relation to exercise adherence behaviour in CLBP.

Two online abstracts described studies that investigated adherence prescribed home exercise in a CLBP sample (Lonsdale et al., 2014; Freson et al., 2012). In 2012, Lonsdale and colleagues' published a protocol for an RCT investigating relationships between communication style and adherence to prescribed home exercise in CLBP (CONNECT trial) (Lonsdale et al., 2012). In this study, physiotherapists received eight hours of communication skills training to assist them in supporting the psychological needs of their CLBP patients. Adherence behaviour was assessed using two questions used in a previous study investigating adherence to prescribed exercise post anterior cruciate ligament (ACL) reconstruction surgery (Chan et al., 2009). An additional assessment of adherence behaviour included percentage of home exercise completed per week. Furthermore, the SIRAS was used to assess physiotherapist rating of patient adherence.

The results of Lonsdale and colleagues' (2012) study have not yet been published (October, 2015). However, a recent published abstract stated that the intervention improved adherence in the experimental group at 12 weeks (Lonsdale et al., 2014). Although, there were no significant differences between groups at 24 weeks. It is difficult to further explain these findings without information regarding analyses of hypothesized mediating factors (e.g. pain, disability and fear-avoidance beliefs) in this study. A future publication will likely assist in providing additional explanation for short-term and long-term differences in exercise adherence behaviour[5].

Freson and colleagues (2015) published the second abstract that was identified during the updated search for CLBP studies investigating adherence to prescribed home exercise. Their study included two CLBP samples that attended conventional physiotherapy treatment and were prescribed home exercises to continue post-treatment. The experimental group were also asked

[5] Authors of the study were contacted (15th August 2015) requesting further details regarding the CONNECT trial. However, there has been no response to date (October 2015).

to complete an online diary to record daily pain levels and exercises completed. The experimental group were reported to have completed 68 percent of their exercises at 6 months, whereas the control group were reported to have completed their exercises 'some of the time' (interpreted as 25-50%). These findings suggest that adherence behaviour was assessed using different measures in each group. However, measures assessing adherence behaviour are not clearly stated in the abstract. Freson and colleagues (2015) concluded that online journaling successfully improved exercise adherence behaviour in a CLBP sample.

In addition to finding differences in adherence behaviour, Freson and colleagues (2015) found no differences in pain or disability between groups at 6 months. These findings indicate that adherence behaviour was not related to clinical outcome in this study. In addition to this, a trial identified in Study 1 found that better adherence behaviour at 5 years was associated with higher levels of pain and disability (Friedrich et al., 2005). Both of these studies suggest that relationships between adherence behaviour and clinical outcome are important to investigate further in order to understand the influence of different factors on clinical outcome. However, findings from Study 1 indicated that CLBP studies rarely focus on relationships between clinical outcome and exercise adherence behaviour.

A key issue that may explain diversity in findings regarding adherence behaviour and clinical outcome is the lack of reliable and valid measures to assess exercise adherence behaviour (Friedrich et al., 2005). Study 1 highlighted the lack of standardised measures of adherence to prescribed home exercise in CLBP. The four recent CLBP studies described in this section assessed adherence behaviour using similar unstandardized measures as were used in trials identified in Study 1. For example, mean daily duration of exercise (Hügli et al., 2015), percentage of daily exercises performed (Lonsdale et al., 2014; Freson et al., 2015) and the SIRAS to provide physiotherapist reports of adherence behaviour (Lonsdale et al., 2014; Hügli et al., 2015). Saper and

colleagues' (2014) protocol states that self-report data will be collected regarding home exercises completed. However, there is no mention in the protocol of how this data will be obtained (e.g. home exercise diary or questionnaire) or how adherence behaviour will be analysed (e.g. percentage of exercises completed or duration of exercise completed). Evidently, heterogeneity of measures assessing exercise adherence behaviour in CLBP remains a problem and suggests a cogent rationale for the work undertaken in Study 2 of this thesis.

## 8.4. Study 2: Results of the development of the EARS and issues of exercise adherence measurement

This section discusses issues related to exercise adherence measurement in CLBP and the contribution of the EARS to the CLBP research literature. Firstly, recent systematic reviews investigating measures of exercise adherence behaviour provide information regarding the state of adherence measurement in the exercise adherence research literature at the current time (8.4.1.). The discussion then focuses on difficulties that arose when planning the development of the EARS (8.4.2.). These difficulties refer to issues of definition, scoring and interpretation of exercise adherence behaviour. Subsequently, issues encountered assessing exercise adherence behaviour in the present research are discussed (e.g. problems obtaining physiotherapist ratings of adherence behaviour) (8.4.3.). Recommendations (e.g. triangulation) are suggested for the wider field of exercise adherence research regarding the general assessment of adherence behaviour. Finally, conclusions regarding the current state of adherence measurement in CLBP are summarised (8.4.4.).

### 8.4.1. Current issues of exercise adherence measurement in CLBP

This thesis reported the development and initial psychometric evaluation of the EARS (Chapter 4). The EARS is a 6-item measure assessing adherence to prescribed home exercise recommended by a healthcare provider (HCP) (Appendix 4b). To the authors' knowledge, the EARS is the first validated measure that assesses self-reported adherence to prescribed home exercise in

CLBP. Exploratory factor analysis (EFA) revealed a one factor solution explaining a total of 66 percent of the variance in adherence to exercise. Internal consistency and item response methods indicated that the reliability of the EARS was acceptable, and test re-test reliability was high. Replication is needed, but initial evidence suggests that the EARS is a promising measure of adherence behaviour for use with a CLBP sample.

The EARS was developed in response to findings from systematic reviews investigating exercise adherence interventions in musculoskeletal (MSK) conditions (e.g. Jordan et al., 2010; McLean et al., 2010) and the systematic review conducted for Study 1 of the present thesis (Beinart et al., 2013; Chapter 4). Both reviews highlighted the lack of standardised measures of exercise adherence behaviour in MSK conditions. Since the development of the EARS in 2012, no further new measures of exercise adherence behaviour have been found by systematic reviews investigating measures assessing exercise adherence behaviour. Bollen and colleagues (2014) investigated measures assessing prescribed home exercise in long-term physical conditions (including CLBP). Furthermore, Hall and colleagues (2015) investigated measures assessing adherence to non-pharmacologic recommendations in mixed chronic MSK conditions (including CLBP). Both systematic reviews indicated the need for psychometrically evaluated measures to assess adherence to prescribed exercise for individuals with long-term health conditions. The findings of the two systematic reviews suggest that there remains a gap in the research literature for a measure to assess exercise adherence behaviour for long-term conditions. The development and initial psychometric evaluation of the EARS demonstrates an initial attempt to bridge that research gap.

### 8.4.2. Definition and scoring of exercise adherence behaviour in CLBP

Research literature investigating exercise behaviour in long-term conditions has argued for the importance of a standardised assessment of exercise adherence behaviour (e.g. Bollen et al., 2014; Beinart et al., 2013; Jordan et al., 2010; Hall & Fong, 2015). However, there is no guidance regarding what components of

exercise behaviour or adherence behaviour would be most useful to assess to provide information that may assist in improving outcome. At present, there is no single exercise programme that is most effective for the treatment of CLBP (Hayden, Cartwright, Riley, & van Tulder, 2012; van Middelkoop et al., 2011). Therefore, exercise treatment is likely to vary across individuals with CLBP. For this reason, the EARS does not provide any cut-off score to dichotomise individuals into groups based on adherent and non-adherence exercise behaviour. An important strength of the EARS is its ability to provide an overall general assessment of level of exercise adherence behaviour for a condition where exercise prescriptions are not uniform. Furthermore, this allows the EARS to be considered for use in conditions other than CLBP where prescribed home exercise is a part of the treatment programme. In order to provide guidance that may lead to improvements to the EARS and assist the development of future measures assessing exercise adherence behaviour, definition(s) of adherence behaviour with regards to exercise must become established.

A definition of adherence behaviour that is used throughout studies investigating adherence exercise programmes in MSK samples is “the extent to which a person’s behaviour [....] corresponds with agreed recommendations from a healthcare provider” (World Health Organisation, 2003). This is a general definition that was originally developed to explain adherence behaviour with regards to a range of health behaviours (e.g. exercise, diet and medication adherence) prescribed for individuals with long-term conditions. The development of a standard definition that is more precise and relevant to exercise adherence behaviour would be an initial step towards standardising the assessment of exercise adherence behaviour. Furthermore, a comprehensive definition that is appropriate across long-term conditions may aid the move towards a more detailed, standardised definition(s) of adherence behaviour within specific conditions.

It seems logical to begin the process of developing standardised definition(s) of exercise adherence behaviour by examining features of exercise behaviour that may be relevant across exercise programmes, regardless of condition. FITT guidelines (American College of Sports Medicine, 2013) are suggested to provide a simple method of summarising exercise prescriptions for individuals with chronic MSK conditions (O'Riordan, Clifford, Van De Ven, & Nelson, 2014; Barkley, 2010). FITT guidelines refer to the Frequency, Intensity, Time and Type of prescribed exercise, all of which are relevant to most exercise prescriptions. The assessment of exercise adherence behaviour using the FITT guidelines may provide a useful basis for comparison of adherence behaviours both within and across different long-term conditions. This, in turn, would provide an overall picture of which components of exercise behaviour are most influenced by non-adherence to prescribed exercise. Thus, improved definition of exercise adherence behaviour may provide much needed clarity when assessing adherence behaviour. Based on a similar approach suggested by Abraham and Michie (2008) to specify content of behaviour change interventions by taxonomy, it is expected that improved definition may provide a better understanding of different components of adherence behaviour and how they relate to clinical outcome. Thus, informing studies of specific components of adherence behaviour that may require intervention to improve outcome.

In addition to lack of adequate definition of exercise adherence behaviour, a further difficulty encountered when developing the EARS related to variations in scoring methods used to interpret adherence behaviour in the CLBP research literature**.** CLBP researcher have often used cut-off scores to classify exercise adherence behaviour (e.g. Hayden et al., 2005; Friedrich et al., 2005; Friedrich et al., 1998; Linton et al., 1996). This is perhaps partially due to the frequent use of cut-off scores throughout medication adherence literature (e.g. Sjölander et al., 2013; Glombiewski et al., 2012) on which much of the exercise adherence research has been based. The use of a continuum for interpreting adherence behaviour is considered a substantial strength of the EARS as this allows for increases and decreases in adherence behaviour to be assessed on an

individual and group level. Furthermore, there are statistical advantages for the use of a continuum, such as preserving the power required to detect effects between scores on the EARS and patient outcome. Scoring of adherence behaviour is discussed in this section with regards to exercise and medication adherence literature.

Lack of guidance regarding scoring and interpretation of adherence behaviour has led to the use of cut-off scores to define exercise adherence behaviour in CLBP (e.g. Hayden et al., 2005). Hayden and colleagues (2005) conducted a systematic review investigating strategies for using exercise therapy to improve outcome in CLBP. They used 'best estimates' to describe adherent and non-adherent exercise behaviour when arbitrary adherence cut-offs used in original research studies. For example, completion of 49 percent or less of prescribed home exercises indicated non-adherence. No explanation was provided to support their choices of cut-off scores. However, it is possible that their reasons for using arbitrary cut-off scores related partially to difficulties encountered in the initial stages of developing the EARS (e.g. lack of standard definition(s) and guidance regarding scoring and interpretation of adherence behaviour).

Arbitrary cut-off scores have also been used to define exercise adherence behaviour in chronic health conditions other than CLBP. For example, a recent study assessing adherence to exercise in patients with heart failure divided patients into three categories of adherence behaviour based on classification used to evaluate adherence to hypertensive medication (i.e. adherent ≥ 80%, partially adherent 20-79% and non-adherent < 20%) (Conraads et al., 2012). The researchers explained their rationale for using these cut-off scores as being based on the same scoring system used to assess medication adherence behaviour for patients with heart failure. However, cut-off scores relating to medication adherence behaviour do not provide any indication of percentage of exercise adherence behaviour necessary to improve outcome. This is another example of the arbitrary use of cut-off scores to define exercise adherence behaviour in the exercise research literature. The research stated in this section

demonstrates the ongoing problem of appropriate scoring and interpretation of exercise adherence behaviour in long-term conditions where prescribed home exercise plays an important role in outcome.

Level of medication adherence required to achieve an effective result is known for certain health conditions (e.g. Machtinger & Bangsberg, 2007). The use of cut-off scores in medication adherence research can therefore provide important information about which individuals are most at risk of poor outcome. However, in CLBP research, the level of adherence to prescribed home exercise that is necessary to improve clinical outcome is not currently known. The EARS does not provide information regarding specific scores that refer to different levels of adherence behaviour for this reason. However, recent medication adherence research investigating a novel framework to assess adherence behaviour has suggested that adherence should be assessed on a continuum to reflect the extent to which any treatment recommendation is adopted (Jackson et al., 2014). This has important implications for exercise adherence research where extrapolation from medication adherence research is common.

### 8.4.3. Assessment of exercise adherence behaviour in the present research

Problems regarding definition, scoring and interpretation of exercise adherence behaviour are an ongoing problem in the CLBP and MSK research literature. Further validity and reliability testing is necessary for the EARS to be classed as a psychometrically robust measure of exercise adherence behaviour for use with a CLBP sample. Nonetheless, the EARS demonstrates an important step towards standardised assessment of exercise adherence behaviour in CLBP. Furthermore, a measure such as the EARS provides a preliminary basis for better use of triangulation methods to provide more robust assessment of adherence behaviour than is currently available.

The assessment of exercise adherence behaviour using triangulation of adherence measures may increase the reliability of results compared with using a single method of measurement (Tenenbaum & Eklund, 2012; World Health Organisation, 2003). In the present research, the EARS provided a reliable, general measure of self-report adherence for general prescribed home exercise. Objective measures of exercise adherence behaviour were not used due to the inability of such measures to assess the types of exercises prescribed for CLBP (Bollen et al., 2014; Yang & Hsu, 2010). In addition to this, objective measures are most likely to be worn by more adherent individuals. This might introduce bias into the results of data obtained from objective measures as they are likely to worn by more adherent participants. Objective measures may also act as an intervention to remind participants to exercise, leading to unrealistic data about the true prevalence of exercise adherence behaviour in the CLBP sample.

In order to triangulate adherence assessment for Study 3 (Chapters 5-7), two further assessments of adherence behaviour were obtained in addition to the EARS. The Prescribed Exercise Questionnaire (PEQ) (Appendix 4a) asked participants how often they were asked to exercise and how often they were exercising at the present time. Further assessment of adherence behaviour was provided by physiotherapists using SIRAS. Difficulties obtaining physiotherapist reports of adherence behaviour led to SIRAS data for only six participants. Main reasons for this included lack of time, frequent rotation within physiotherapy departments and high turnover of physiotherapists. In addition to this, in certain cases, participants were treated by multiple on a one-to-one or group level. This led to uncertainly amongst physiotherapists regarding who would complete the SIRAS.

Physiotherapists that were contactable (i.e. still working in the physiotherapy department) all stated lack of time as their reason for not completing the SIRAS. Prior to Study 3, physiotherapists selected email as the best method to collect SIRAS data. On reflection, more data may have been collected if a paper

questionnaire was provided for physiotherapists at 3 month-follow up. This would have necessitated additional visits to the three physiotherapy departments by the researcher. This may not have been feasible due to the time constraints of the present research. However, having a smaller final dataset that included three types of adherence data may have provided more detailed information regarding adherence behaviour than a larger dataset including less triangulated data. Moreover, successful triangulation of adherence data would have provided further validation for the EARS questionnaire.

Previous studies collecting physiotherapist report of patient adherence may provide useful information so future studies may be less likely to experience problems found in Study 3. However, few studies assessing exercise adherence behaviour in CLBP samples have collected physiotherapist adherence reports (Beinart et al., 2013). Two recent CLBP studies that have obtained physiotherapist report have used the SIRAS (e.g.Lonsdale et al., 2014; Hügli et al., 2015). However, Lonsdale and colleagues (2014) findings have only been published in an abstract in relation to patient self-report of adherence behaviour. Therefore, no information is known regarding level of data obtained from physiotherapists using the SIRAS.

Hügli and colleagues (2015) obtained SIRAS data for all 20 participants. However, their study was particularly small due to being a pilot RCT. In addition to this, SIRAS data were collected at the end of treatment, rather than at a later stage of follow-up as was the case of the present research. Study 3 included a follow-up sample almost four times larger (n=74) than Hügli and colleagues (2015) and collected data post-treatment, rather than at end of treatment. A large sample, with post-treatment follow-up by a single researcher, is likely to present with more difficulties obtaining data than a smaller sample with follow-up at the end of treatment. A further potential reason for problems obtaining follow-up data for Study 3 may be due to lack of direct involvement of physiotherapists in the study. Hügli and colleagues (2015) study included in an intervention requiring physiotherapists to be active part of the research. In Study

3, physiotherapists were not directly involved in the study. Therefore, the study may have been less of a priority than other issues more directly relevant to a busy NHS physiotherapy department. Comparison of Hügli and colleagues (2015) study to the Study 3 assists in providing potential explanation regarding difficulties obtaining SIRAS data in the present research. On reflection, the use of incentives (e.g. a prize draw each month for participating clinicians) may have been a useful tool to assist in reducing this problem.

Assessment of adherence behaviour on multiple levels (e.g. participant report and physiotherapist report) may be becoming more commonplace in CLBP research (e.g. Hügli et al., 2015; Lonsdale et al., 2012). The present research used only self-report measures to assess adherence behaviour. However, assessment of adherence behaviour using both subjective and objective measures where possible, may reduce problems related to self-report (e.g. response bias). However, even where prescribed exercises are suitable for assessment using objective measures (e.g. a pedometer to measure step-count), limitations of objective measures would also have to be considered. For example, not all pedometers have been shown to accurately assess step count (Schneider et al., 2003). It is importance to evaluate the accuracy and reliability of objective and subjective measures used to assess exercise adherence behaviour. Triangulation of adherence assessment using a range of psychometrically robust measures would provide more robust findings regarding adherence behaviour in CLBP than are available at the present time. Further psychometric evaluation of measures may in turn provide guidance describing appropriate methods for the assessment of exercise adherence behaviour in research and clinical settings.

### 8.4.4. Summary of Section 8.4: The development of the EARS and issues of exercise adherence measurement

This section has discussed problems regarding lack of definition(s) of adherence and resulting problems of scoring and interpretation of adherence behaviour. Two recent systematic reviews (Bollen et al., 2014; Hall & Fong,

2015) came to the same conclusion as the systematic review conducted in Study 1 (Chapter 3) of the present research. That is, that there is no published psychometrically evaluated measure to assess exercise adherence behaviour in CLBP. The development of the EARS appears to be a novel contribution to the CLBP and exercise adherence research literature. The EARS represents an initial step towards the effective assessment of exercise adherence behaviour in CLBP. However, the EARS is only in preliminary stages of psychometric evaluation. Future research regarding next steps in the development of the EARS are described later in this chapter. Improvement in the psychometric evaluation of self-report measures assessing adherence to prescribed exercise would lead to simple, reliable and cost-effective measurement of exercise adherence behaviour. Therefore, even where objective activity monitors are inappropriate for assessing certain prescribed exercises, a number of valid and reliable suitable measures would be available for triangulation purposes. However, problems of definition, scoring and interpretation of adherence behaviour should be considered by future research investigating assessment of exercise adherence behaviour. A greater understanding of these problems will provide a valuable basis for the development of new measures and the evaluation of existing measures of adherence behaviour.

## 8.5. Study 3: Factors predicting adherence to prescribed home exercise in CLBP

Study 3 found that clinical and demographic factors predicted poorer exercise adherence behaviour in a CLBP sample. These factors were longer duration of pain, higher present pain, lower educational level and being female. This section is divided into two main areas. Firstly, the two clinical factors (i.e. duration of pain and present pain) that predicted exercise adherence behaviour are discussed. Secondly, the discussion focuses on the two non-modifiable demographic factors (i.e. gender and education) that predicted adherence behaviour.

The two main sections are divided into four smaller areas. Firstly, clinical factors predicting adherence behaviour in Study 3 are discussed in relation to extant CLBP and MSK research literature (8.5.1.). Secondly, demographic factors that predicted adherence behaviour are discussed in relation to CLBP and MSK research (8.5.2.). Findings regarding gender (8.5.2.1.) and level of education (8.5.2.2.) and exercise behaviour in healthy samples provide valuable information where evidence in CLBP is lacking. Thirdly, research literature from the well-established field of medication adherence is discussed in relation to the findings of the present research. (8.5.3.). An overall summary of the findings is provided in Section 8.5.4.

### 8.5.1. Clinical factors and exercise adherence behaviour

Longer duration of pain and higher present pain predicted poorer adherence to exercise in Study 3. Duration and present pain are commonly assessed in CLBP studies. However, present pain data are generally used to investigate changes in pain pre- and post-intervention. In contrast, data regarding duration of pain tend to be used descriptively alongside demographic data (e.g. Vong et al., 2011). Researchers rarely include both types of pain data when investigating relationships between factors hypothesised to influence adherence and adherence behaviour itself. Therefore, there is little previous research that can assist in understanding further the impact of pain on adherence to prescribed home exercise in CLBP.

The systematic review conducted for Study 1 (Chapter 3) found only one article that investigated pain in relation to adherence to prescribed home exercise in a CLBP sample (Donzelli et al., 2006). Donzelli and colleagues (2006) found that people with higher baseline present pain displayed better adherence behaviours post-treatment (see Chapter 7 discussion, Section 7.5.2.). These findings oppose the findings of the present research that higher pain leads to poorer adherence. However, Donzelli and colleagues' (2006) findings are not easily comparable with Study 3 due to results being based on comparison of populations, without any significance testing. This leads to difficulties surmising

conclusively regarding the predictive value of present pain in relation to adherence behaviour in their research.

Duration of pain and present pain have not been investigated in relation to prescribed home exercise in more recent CLBP samples (e.g. Hügli et al., 2015; Lonsdale et al., 2014; Saper et al., 2014; Freson et al., 2012). However, a systematic review investigating barriers to physiotherapy treatment adherence (including adherence to prescribed home exercise) in mixed MSK samples (Jack et al., 2010) found evidence that is both contradictory and supportive of findings from the present research (i.e. Dobkin et al., 2006; Sluijs et al., 1993). Sluijs and colleagues (1993) found that higher baseline present pain was associated with better adherence to prescribed home exercise in a mixed MSK sample (27% low back pain). Research with women with fibromyalgia also found that higher baseline present pain led to better adherence to prescribed home exercise throughout a 12 week programme (Dobkin et al., 2006). However, Dobkin and colleagues (2006) found that higher upper body pain predicted better adherence to prescribed aerobic home exercises, whereas higher lower body pain predicted poorer adherence to prescribed stretching home exercises. A further study in Jack and colleagues (2010) systematic review found that higher levels of baseline present pain predicted poorer adherence behaviour in people with osteoarthritis affecting their knees (Rejeski, Brawley, Ettinger, Morgan and Thompson; 1997). However, on closer inspection it was found that baseline pain predicted supervised exercise (i.e. exercise supervised and completed in-clinic), but was not a significant predictor of prescribed home exercise in that study.

Evidence from the aforementioned MSK samples regarding baseline present pain is inconsistent. In the case of Sluijs and colleagues (1993) research, causal inferences cannot be made due to the use of correlational analysis to investigate their data. Dobkin and colleagues (2006) used linear multiple regression analysis to investigate the predictive value of present pain on adherence behaviour in their sample of women with fibromyalgia. Therefore,

their findings are more easily compared to the present research where regression analysis was also performed. However, Dobkin and colleagues (2006) results are not directly comparable to the findings of Study 3 as factors associated with adherence are likely to vary between people with different MSK pathologies (Jack et al., 2010). Furthermore, their finding that pain predicts adherence to different types of exercise depending on site of pain, further suggests caution should be taken when comparing factors predicting adherence behaviour across conditions. With this in mind, findings from studies investigating MSK samples may be helpful to provide information where studies including solely CLBP samples are lacking.

The one study that investigated present pain in relation to adherence to prescribed home exercise in a CLBP sample found opposing results to the present research (Donzelli et al., 2006). However, as mentioned previously, lack of statistical analysis means that inferences cannot be made regarding the predictive value of pain on adherence behaviour. Nonetheless, discussion of Study 3 (Chapter 7, Section 7.5.2.) explores potential explanations as to why higher present pain may have led to better adherence in Donzelli and colleagues (2006) study and not in Study 3 (e.g. additional supervision).

It is difficult to reach a consensus regarding the predictive value of baseline present pain on adherence to prescribed home exercise in either CLBP or other MSK samples due to the variety of methods used. A key reason for inconsistencies in findings across exercise adherence literature is suggested to be the lack of a standardised, reliable and valid measure to assess adherence behaviour (e.g. Hall et al., 2015; Bollen et al., 2014; Beinart et al., 2013; Jordan et al., 2010; Friedrich et al., 2005). Use of a validated measure of adherence behaviour would add robustness to findings in a field of research where the reliability of current results is hindered by a lack of a standardised measurement tool. The issue of adherence measurement is discussed throughout this thesis and illustrates the need for more rigorous measurement of adherence behaviour in exercise research. The publication of a recent systematic review (Bollen et

al., 2014) and a protocol for a systematic review and meta-analysis (Hall et al., 2015) investigating tools assessing exercise adherence behaviour, suggests that this problem of measurement is widespread in current research. Thus, future researchers should have information that allows them to improve measurement of adherence behaviour, providing more consistent data than is currently available.

### 8.5.2. Demographic factors and CLBP and MSK literature: A summary

Demographic variables that predicted non-adherence to prescribed home exercise in CLBP in Study 3 (Chapters 5-7) were lower educational level and being female. Extant CLBP research supports the findings of Study 3 that being female predicts non-adherence to prescribed home exercise (e.g. Mannion et al., 2009; Hügli et al., 2015). Furthermore, comparable results have been found regarding gender and exercise adherence behaviour in a mixed chronic neck pain and CLBP sample (Engström & Öberg, 2005). Hügli and colleagues (2015) have contributed further to these findings by demonstrating that type of exercise moderates the role of gender in CLBP. In line with the findings in Study 3, they found that women displayed poorer adherence than men for conventional physiotherapy prescribed home exercises. However, women displayed better adherence than men for prescribed home exercise that included an augmented feedback component. Of the studies mentioned here, Hügli and colleagues (2015) were the only researchers that included an unconventional home exercise component (i.e. augmented feedback). Their findings suggests that gender specific unconventional prescribed home exercises may play a role in improving adherence behaviour in women with CLBP. However, for reasons discussed in Section 8.2 of this chapter (e.g. small sample and lack of follow-up), findings from Hügli and colleagues' (2015) may not be generalisable to the wider population of individuals with CLBP.

The findings of the present research are in accordance with prior CLBP research literature indicating that women are less adherent than men to conventional physiotherapy prescribed home exercises. The CLBP research

literature has not described relationships between level of education and exercise adherence behaviour. However, level of education has been investigated in a mixed MSK sample where more highly educated patients were less adherent to prescribed home exercise than those with lower education levels (Sluijs et al., 1993). These findings were in contrast to initial expectations of Sluijs and colleagues (1993) and also to the findings of Study 3. It is problematic to directly compare the findings of Sluijs and colleagues (1993) study to the present research due to differences in measurement of exercise adherence behaviour. Sluijs and colleagues (1993) calculated a percentage for adherence behaviour based on a single question ('did you manage to exercise regularly last week?'). The researchers also removed participants that they labelled as partially adherent from the analysis. However, they did not define partial adherence. This leads to difficulties interpreting what exactly is meant by adherent and non-adherent behaviour in Sluijs and colleagues' (1993) study. This is a further example of issues of definition and scoring that affect ability to surmise conclusively from the findings of much of the exercise adherence behaviour research.

The paucity of research investigating gender and education in relation to exercise adherence behaviour has led to difficulties conclusively surmising the influence of these factors on adherence to prescribed home exercise in CLBP. Therefore, evidence from healthy samples and medication adherence research is discussed to further assist our understanding of the role of demographic factors in these related areas of research. This, in turn, may inform the design of future research to investigate further the influence of demographic factors on exercise adherence behaviour in CLBP.

#### 8.5.2.1. Gender and exercise behaviour in healthy samples

Examination of demographic factors assessing exercise behaviour in healthy samples may provide valuable information where evidence in CLBP and related samples is lacking. A Department of Health (2011) survey found that 40 percent of men and 28 percent of women in England follow Chief Medical Officer

guidelines to exercise moderately for 2.5 hours per week (Department of Health, 2011). Furthermore, a recent British Heart Foundation survey found that women exercised less than men in every region of England, including London, where the present research was conducted (Townsend, Wickramasinghe, Williams, Bhatnagar, & Rayner, 2015). These population-wide findings are in accordance with the results of Study 3 and recent CLBP research (e.g. Hügli et al., 2015; Mannion et al., 2009). Therefore, it appears that gender differences in exercise behaviour in the general population may persist in those with CLBP.

Investigation of motivational factors in healthy samples suggests that the type of exercise may moderate the influence of gender on exercise behaviour. Exercise behaviour research in healthy samples has tended to focus on self-determination theory (SDT) (Deci & Ryan, 2002) as a framework to explain gender differences (Chowdhury, 2012; Egli, Bland, Melton, & Czech, 2011). According to SDT, motivations can be either intrinsic or extrinsic. At a basic level, intrinsic motivation refers to performing an activity due to satisfaction and enjoyment and extrinsic motivation refers to performing an activity to achieve an independent outcome (Deci & Ryan, 2002). Healthy men and women have displayed differing motivations regarding the initiation and maintenance of exercise behaviour. For example, two recent studies found that women were more motivated to exercise based on extrinsic factors (e.g. weight management and appearance) and men were more motivated by intrinsic factors (e.g. enjoyment of exercise and strength) (Chowdhury, 2012; Egli et al., 2011). A systematic review investigating SDT and exercise behaviour found that the majority of studies did not reported gender differences (Teixeira, Palmeira, & Vansteenkiste, 2012). However, for those that reported gender differences, findings were in accordance with the two studies mentioned here.

Exercise behaviour research has found that women are less likely to exercise than men (e.g. Townsend et al., 2015). Furthermore, women are more motivated to exercise by extrinsic factors than intrinsic factors (e.g. Teixeira et al., 2012). However, a recent systematic review found an overall effect for the

role of extrinsic factors in the initiation of exercise and intrinsic factors in the maintenance of exercise (Teixeira et al., 2012). This suggests that intrinsic motivation may be an important factor that influences long-term adherence to exercise. Furthermore, this may be one explanation of why women are less likely to exercise than men. Motivational factors influencing the initiation and maintenance of exercise behaviour requires investigation with regards to gender differences (Teixeira et al., 2012). This may be particularly relevant with regards to home exercise prescriptions in CLBP where long-term self-management is recommended in order to improve clinical outcome (Beattie & Silfies, 2015).

Gender-related barriers to exercise that have been found in healthy samples may provide useful information regarding possible areas of intervention to improve adherence behaviour. A population level survey found that lack of time is the most common barrier to performing exercise in men and women (Murray & Ipsos, 2006). Both men and women stated that family responsibilities played a role in lack of time to exercise. However, women were more likely to state family responsibilities as their primary reason for not exercising. A recent qualitative study found gender differences when investigating barriers to exercise in working mothers and fathers (Mailey, Huberty, Dinkel, & McAuley, 2014). In contrast to the 2006 survey, this study found that men were more likely than women to state family responsibilities as a barrier to exercise. However, men described a responsibility to their wives (e.g. exercising instead of spending time with their wife) as a reason for not exercising. Whereas, women described a responsibility to their children (e.g. guilt for exercising rather than being with their children) as a reason for not exercising. Lack of support was also described as a reason affecting both men and women. However, men described a lack of community support. Whereas, women described a lack of spousal support and role models (e.g. a role model who appears able to balance family and working life with frequent exercise).

Differences between the results of the 2006 survey and Mailey and colleagues' (2014) study are not surprising due to their different methodologies. Qualitative and quantitative methods of analyses are not comparable in terms of quantifying barriers to exercise. Furthermore, qualitative interviews provide more opportunity than a survey to discuss barriers to exercise in detail. Another reason for contrasting findings regarding gender and family responsibilities relates to the specific nature of the sample in the qualitative study. Mailey and colleagues' (2014) interviewed 13 working mothers and 12 working fathers, whereas the 2006 survey included men and women with varied family status. Nonetheless, findings of gender differences in relation to barriers to exercise provide useful information that may inform CLBP research of potential factors for intervention.

#### 8.5.2.2. Education and exercise behaviour in healthy samples

Study 3 (Chapters 5-7) found that lower level of education predicted poorer adherence to prescribed home exercise in CLBP. This finding is supported by general health behaviour research where lower level of education has predicted less healthy choices across a range of health behaviours (e.g. smoking, poor dietary choices, being sedentary) (Roberts et al., 2013). Exercise behaviour research has supported further the findings of Study 3 with regards to participation in exercise behaviour in healthy adults (Heinrich, Jokura, & Maddock, 2008). Furthermore, this relationship has been shown to remain in healthy samples after controlling for factors that may be potential confounders with level of education (e.g. low income and low socio-economic status) (Robinson et al., 2004). However, in a recent review of systematic reviews investigating correlates and predictors of exercise behaviour in healthy adults, only three out of six reviews reported level of education and only one study (Trost, Owen, Bauman, Sallis, & Brown, 2002) supported the findings of Study 3 (Bauman et al., 2012).

Two systematic reviews have found inconclusive evidence regarding the effects of level of education on exercise behaviour in healthy adults

(Kaewthummanukul & Brown, 2006; Rhodes et al., 1999). Reasons for inconsistencies in findings may be due to numerous factors related to level of education, such as, intelligence, social class, occupation and health literacy (Roberts et al., 2013). For example, better education is positively correlated with health literacy and numeracy, thus, leading to better ability to access information regarding the benefits of exercise (El-Sayed et al., 2012, cited in Roberts et al., 2013). It is difficult to fully comprehend the relationship between level of education and exercise behaviour without more detailed socio-economic assessment in healthy samples. Furthermore, assessment including multiple variables would provide more comprehensive evaluation than is available from Study 3 (Chapters 5-7) of the present research investigating exercise behaviour in a CLBP sample. This, in turn, would provide a more detailed understanding of whether level of education, or related factors, predict unique variance in exercise adherence behaviour in CLBP.

Gender and level of education are rarely assessed in CLBP research investigating predictors of exercise behaviour. As gender and level of education are factors that do not change with the development of CLBP, research investigating healthy samples has been cited to provide additional information about these factors and their influences on exercise behaviour. Research evidence from healthy samples supports the findings of Study 3 (Chapters 5-7), that women are less likely to participate in exercise behaviour. However, evidence regarding relationships between level of education and exercise behaviour in healthy samples is inconsistent. To add further to our understanding of demographic factors and adherence to prescribed home exercise in CLBP, it may be useful to examine these factors in relation to adherence behaviours other than exercise adherence. Therefore, the influence of demographic factors on medication adherence is briefly discussed to ascertain what information medication adherence literature may add to our understanding of gender and education on adherence behaviours.

### 8.5.3. Demographic factors and medication adherence behaviour

Over the past 50 years, research investigating adherence to medication has found hundreds of predictors of adherence behaviour (Kardas, Lewek, & Matyjaszczyk, 2013). Psychosocial factors (e.g. health attitudes and beliefs) have been shown to play a large role in the prediction of medication adherence, and a much smaller role in prior CLBP and exercise behaviour research in healthy samples (e.g. Kardas et al., 2013; Davis, Jandrisevits, Iles, Weber, & Gallo, 2012; Schulz, Cook, Roller, Fincham, & Gowan, 2007; Horne & Weinman, 1999). Furthermore, in contrast to the findings of Study 3 (Chapters 5-7), gender and level of education have been found to have low or no predictive value across medication adherence literature (e.g. Kardas et al., 2013; Davis et al., 2012; Schulz et al., 2007; Horne & Weinman, 1999). When an effect of gender or level of education has been found in medication adherence literature, it has been a small effect and moderated by sample, treatment regimen and method of assessment (DiMatteo, 2004).

Findings that demographic factors have different levels of influence on exercise adherence behaviour and medication adherence behaviour is unsurprising due to multiple differences between both types of adherence behaviours. For example, there are differences in the type of health behaviours that people are being asked to perform (e.g. performing exercises or taking tablets) and features specific to the illness condition and treatment (e.g. disability in CLBP or monitoring insulin levels in diabetes). Furthermore, there are differences in measurement of adherence behaviour where little is known regarding level of treatment necessary to improve outcome in exercise adherence literature. It is useful to note these distinctions as medication adherence literature has been used as a basis for understanding exercise adherence behaviours where exercise data are not available (e.g. Conraads et al., 2012).

No standardised measures assessing exercise adherence behaviour were found in CLBP or MSK research literature to assist in the development of the

EARS in the present research. Therefore, the Medication Adherence Rating Scales (MARS) was used to inform the initial stages of development of the EARS (Chapter 4). Novel areas of study (e.g. exercise adherence behaviour in CLBP) tend to explore related areas of research in order to gain theoretical and empirical perspective to assist in the development of research and interventions. Medication adherence research has a vast evidence base that remains an important resource for research investigating different adherence behaviours. However, differences in factors predicting exercise and medication adherence behaviours suggest that it may be constructive to focus equally on more closely related exercise behaviour research literature in healthy samples (Lonsdale et al., 2012).

### 8.5.4. Summary of Section 8.5: Factors predicting prescribed home exercise in CLBP

Longer duration of pain, higher present pain, lower educational level and being female, all predicted poorer exercise adherence behaviour in a CLBP sample. Inconsistencies in findings, together with lack of research in CLBP and MSK samples, leads to difficulties understanding relationships between these four variables and adherence to prescribed home exercise. Theory-based interventions for CLBP are required in order to provide a greater understanding of behaviour change so that findings can more easily be translated into clinical practice (Beinart et al., 2013; Lonsdale et al., 2012; Jordan et al., 2010). Exercise behaviour research based on self-determination theory (SDT) in healthy samples has provided useful information regarding gender differences in motivation to exercise (e.g. Chowdhury, 2012). Furthermore, recent use of SDT to promote motivation in a CLBP sample found that it increased short-term adherence to prescribed home exercise (Lonsdale et al., 2014). Evidence presented in this section suggests that interventions based on SDT should be investigated further to determine the role of motivation, and the potential mediating or moderating effects of gender, on exercise adherence behaviour in CLBP. However, a shortcoming of the present research, and much of the prior CLBP research investigating exercise adherence behaviour, is lack of long-term

follow-up. Recommendations for future research are discussed later in this chapter.

## 8.6. Theoretical implications of the present research

Traditional models of health behaviour (e.g. the theory of planned behaviour, TPB; Ajzen, 1991) have been used as a theoretical basis for understanding and predicting engagement in exercise behaviour (e.g. Middleton, 2004). However, where these models have demonstrated their ability to successfully predict intention to act, they explain only a small proportion of actual behaviour (28%) (Sheeran, 2002). Furthermore, they have been criticised for their emphasis on rational and conscious decision-making, plus insensitivity to temporal dimensions of change (Hall & Fong, 2015, 2007; Sutton, 2001). The present research aimed to investigate factors not considered by traditional models of behaviour change. In order to do this, temporal self-regulation theory (TST) (Hall & Fong, 2007) was introduced in Chapter 1 as a health behaviour theory that may be more relevant than traditional theories to the present research.

This section briefly reiterates theories and models of health behaviour that were considered when developing Study 3 (8.6.1.). Next, discussion focuses on the role of demographic factors as explanatory variables in theories and models of behaviour change (8.6.2.). Last, the importance of acknowledging executive function deficits in the treatment of CLBP is discussed (8.6.3.). Theory-based interventions investigating adherence to exercise in CLBP are recommended to assist the translation of research findings into clinical practice. A model of behaviour change techniques that has recently been used to explain behaviour change in medication adherence behaviour is suggested to enable comprehensive study of exercise adherence behaviour in future research.

### 8.6.2. Theories and models used to inform the present research: A recap

Previous CLBP and MSK research literature informed the present research regarding gaps in the evidence base that required further study. In addition to this, the vast evidence base of medication adherence research literature

provided a wider understanding of adherence behaviour for the development of studies in the present research. Medication adherence behaviour has been categorised as intentional or unintentional (Mukhtar et al., 2014; Brady & Weinman, 2013; Lehane & McCarthy, 2007). Factors that have been associated with intentional and unintentional adherence behaviour have lacked consistency across medication adherence literature (Lehane & McCarthy, 2007). Additionally, evidence has shown extensive overlap between factors that have previously been described as either intentional or unintentional (e.g. Gadkari & McHorney, 2012). It has also been found that the categories of intentional and unintentional adherence behaviour do not provide any description of behaviour change (Jackson et al., 2014). For these reasons, these categories are now considered unlikely to elucidate the study of adherence behaviour (Jackson et al., 2014). Jackson and colleagues (2014) describe a taxonomy where determinants of adherence behaviour (including exercise adherence behaviour) are conceptualised to include mechanisms of behaviour change. Their taxonomy is described later in this chapter in relation to improving theory-based interventions investigating adherence behaviour (Section 8.8.2.).

Previous medication adherence literature provided useful information regarding the wider context of determinants of adherence behaviour and its assessment to inform the present research. However, factors influencing exercise adherence behaviour were not categorised as intentional and unintentional in the present research for the aforementioned reasons. Furthermore, traditional theories of behaviour change were found lacking in their ability to predict exercise behaviour (e.g. Hagger et al., 2002). This, it was posited that executive functions may be able to explain exercise behaviour where traditional theories of behaviour change could not.

Exercise adherence behaviour is a clear example of a behaviour that requires self-regulation in order to be successful and where failure to self-regulate may result in non-adherence (Hagger et al., 2002; Nes et al., 2009). Successful self-regulation appears to rely on executive functions (Nes et al., 2009; Hall et al.,

2008). Furthermore, Hall and colleagues (2008) found that executive functions explained additional variance in exercise behaviour over and above that explained by traditional health behaviour theories in a student sample. Evidence of executive function deficits and neurological changes in CLBP samples (e.g. Wand et al., 2011) led the present researcher to consider the role of executive functions in predicting exercise adherence behaviour in CLBP. The role of executive functions are not easily explained by traditional health behaviour theories (Hall & Fong, 2015, 2007). Therefore, the present research examined recent health behaviour theories that incorporated automatic decision-making processes, in addition to rational decision-making processes, into explanations of exercise behaviour: temporal self-regulation theory (TST) (Hall & Fong, 2007).

Hall and Fong's (2007) TST went beyond traditional behaviour change theories by stating that in addition to intention and beliefs, executive functions are an important automatic predictor of health behaviours that require self-regulation. Components of traditional behaviour change theories, plus the TST model, were used alongside findings from empirical research to inform Study 3 of factors that may influence exercise adherence behaviour in CLBP. The findings of Study 3 identified four factors that predicted adherence to prescribed home exercise in CLBP. These factors were longer duration of pain, higher present pain, lower educational level and being female. These findings extend previous CLBP research by demonstrating that clinical and demographic factors predict exercise adherence behaviour over and above variance explained by psychosocial and executive function factors.

### 8.6.3. Demographic factors and models of behaviour change

Models of behaviour change that were used in the present research were originally developed to explain health behaviours in samples without chronic pain. Therefore, they were not expected to explain the role of clinical factors in exercise adherence behaviour. Demographic factors predicted exercise adherence behaviour in the present research. However, only one commonly

used model of health behaviour includes demographic factors (including gender and level of education) as an explanatory component of health behaviour: the Health Belief Model (HBM; Rosenstock, 1974). The HBM posits that demographic factors influence an individual's perception of their condition (e.g. perceived benefits and barriers of treatment) and their resulting health behaviours. The HBM was not used in the present research as it has been found to explain less variance in health behaviour than other behaviour change models (e.g. the TPB and the Transtheoretical Model, TTM; Procheska & Diclemante, 1983) (Taylor et al., 2006). Furthermore, the HBM has been criticised for not adequately interpreting the influence of demographic factors as predictors of health behaviour (Taylor et al., 2006). This has led to difficulties translating the model into practice, as evidenced by the number of studies that have not included the demographic components of the HBM into the development of research interventions (Taylor et al., 2006).

Findings from the present research, together with evidence from exercise behaviour research literature, indicate that demographic factors play a role in explaining exercise behaviour. This suggests that expansion of current health behaviour theories and models to include demographic factors may be valuable for the development of future CLBP research and interventions. Inclusion of demographic factors into health behaviour models and theories would provide a more inclusive theoretical underpinning than is presently available to explain exercise behaviour in CLBP. This, in turn, may lead to more clearly defined research questions that are more easily interpretable within theoretical frameworks and existing research literature.

### 8.6.4. Acknowledging executive function deficits in the treatment of CLBP

Deficits of planning ability and behavioural inhibition were found in the present CLBP sample. These deficits did not predict exercise adherence behaviour as assessed by the EARS in the current study. However, other research has demonstrated that executive functions play a role in the uptake of healthy behaviours (e.g. Hall, 2012; Hall & Fong, 2007). Therefore, the role of executive

functions in predicting exercise behaviour should not be discounted in decisions regarding a suitable theory-base for future CLBP research. Hall and Fong's (2007, 2015) TST is suggested as a suitable theoretical framework for future research to explore further the role of executive functions and exercise adherence behaviour in CLBP.

The TST incorporates the role of executive functions (including behavioural inhibition) to explain the initiation and maintenance of exercise behaviour in healthy samples (see Chapter 1 for detailed explanation of the TST). The findings of the present research indicate that executive function deficits are not related to exercise adherence behaviour. However, bi-directional relationships have been found between aerobic exercise and resistance training and executive functions (e.g. Best et al., 2014; Liu-Ambrose et al., 2012; Davis et al., 2011; Liu-Ambrose et al., 2010; Smith et al., 2010). Furthermore, executive functions in CLBP have been improved using spinal surgery, facet joint injections (Seminowicz et al., 2011) and cognitive behaviour therapy (CBT) (e.g. Shpaner et al., 2014), indicating that they are amenable to change. Therefore, it is suggested that the TST may be useful as a theoretical basis for the role of exercise adherence in maintaining improved executive function status in CLBP. Based on the findings of the present research, the addition of demographic and clinical factors to the TST is suggested to provide a more comprehensive framework for investigating exercise adherence behaviour in CLBP.

## 8.7. Strengths and limitations of the present research

This section summarises main strengths and limitations of each of the three studies described in this thesis. A systematic review was conducted for Study 1 (8.7.1.). A measure to assess exercise adherence behaviour was developed in Study 2 (8.7.2.). Factors predicting adherence to prescribed home exercise were investigated in Study 3 (8.7.3.). Strengths of each study are described prior to discussion of limitations.

### 8.7.1. Study 1: A systematic review

To the author's knowledge, Study 1 was the first systematic review investigating adherence to prescribed home exercise in a CLBP sample. This review was published, thus disseminating useful information regarding factors that may influence adherence to prescribed home exercise in CLBP. The systematic review highlighted a substantial gap in the research literature regarding the lack of standardised measures of exercise adherence behaviour. It also summarised the quality of current CLBP research investigating exercise adherence behaviour. This provides readers with information regarding improvements required for future research to produce more robust findings. This, in turn, may assist in the design and development of future studies in a currently under-researched area.

General limitations relevant to systematic reviews in general are also relevant to the review conducted in Study 1. These limitations include difficulties locating all relevant articles based on chosen search terms and language constraints. Furthermore, bias may result from preconceived notions of the authors of the identified studies, as well as the author of the systematic review (Garg et al., 2008). In addition to this, no suitable quality assessment tool (QAT) was found to evaluate the methodological quality of RCTs in the systematic review. Therefore, a new QAT was developed to allow for the inclusion of additional important criteria that were found to be lacking in other QATs. The new QAT was not a validated tool and may have reduced the robustness of the conclusions of the review.

### 8.7.2. Study 2: The development of the EARS

Exercise programmes are moderately effective at reducing pain and disability in patients with CLBP (van Middelkoop et al., 2010; Hayden et al., 2005). With this in mind, it is especially important that adherence to prescribed exercise can be adequately assessed. To the author's knowledge, the EARS is the first psychometrically evaluated questionnaire that assesses exercise adherence behaviour for individuals with CLBP. Furthermore, the EARS demonstrates an

important step towards standardised assessment of exercise adherence behaviour in CLBP. A key strength of the EARS is its ability to provide an overall general assessment of level of adherence behaviour for a condition where exercise prescriptions are not uniform. This allows the EARS to be considered for use in conditions other than CLBP where prescribed home exercise is a part of the treatment programme. In addition to this, the EARS provides a preliminary basis for better use of triangulation methods to provide more robust assessment of adherence behaviour than is currently available.

The EARS experiences many of the same issues as any self-report measure, such as memory lapses, social desirability and recall bias. However, a limitation specific to the development of the EARS is the small sample size (n=150). No minimum standard exists for performing EFAs (Kline, 2013). Furthermore, time constraints meant that no more than the 150 participants could be recruited. It is acknowledged that the psychometric standing of the EARS may have benefited from a larger sample. It clearly requires additional psychometric evaluation (e.g. discriminant and convergent validity) in order to improve its psychometric standing. In addition to further psychometric evaluation of the EARS, it would be beneficial to further investigate the 10 items assessing reasons for adherence behaviour. This would provide information regarding factors influencing adherence behaviour, as well as level of adherence behaviour that is assessed by the EARS in its current form. After additional psychometric evaluation, the EARS should provide a well-validated, reliable measure of exercise adherence behaviour for use in research and clinical settings.

### 8.7.3. Study 3: Factors predicting adherence to prescribed home exercise in CLBP

Study 3 provided novel findings in an under-researched area that may help to inform future research and treatments for individuals with CLBP. Baseline findings that individuals with CLBP may have certain executive function deficits, add to the growing body of CLBP research literature that has found neurological changes and executive function deficits in CLBP samples (e.g. Seminowicz et

al., 2011; Wand et al., 2011). Furthermore, Study 3 found that demographic and clinical factors, but not executive function and psychosocial factors, predicted adherence to prescribed home exercise in CLBP. These findings highlight gaps in the research literature regarding factors that have rarely been investigated in relation to exercise adherence behaviour in CLBP.

A lower than anticipated recruitment rate and missing data led to a sample size that was smaller than expected for Study 3. This resulted in a reduction in statistical power, meaning that any statistically significant effects would be difficult to detect. As a result of this, findings relating to predictors of adherence behaviour may not be generalisable to other CLBP samples. The inclusion of a priori attrition procedures may have reduced the likelihood of missing data problems and increased generalisability of the findings of the research. An additional limitation of Study 3 relates to length of follow-up (3 months). Longer-term follow-up would be necessary to provide a realistic view of adherence behaviour in a condition where periods of exacerbation and remission are common (Medina-Mirapeix et al., 2009). However, there were time constraints in the present research that did not allow for longer-term follow-up.

Age range was restricted in Study 3 in order to control for potential confounding factors that might otherwise bias the results of the study (i.e. age-related cognitive decline and age-related co-morbid illness). The implications of this age restriction are that it may have minimised the chances of finding an executive function effect on adherence behaviour. This is because an older sample may have included more people with lower levels of executive function, which, in turn, may have had an effect on adherence behaviour. Recent research suggests that age-related cognitive decline may begin as early as 20 years of age (Salthouse, 2012) and that different executive functions decline at different rates depending on the individual (Kievit et al., 2014). Therefore, in retrospect, restricting age to control for age-related cognitive decline in Study 3 may not have been necessary. On reflection, statistical control would have been a better option compared to enforcing an age-restriction when dealing with age as a potential confounding variable.

## 8.8. Research and clinical implications

This thesis presented the first study to investigate the predictive value of executive function, clinical and demographic factors in adherence to prescribed home exercise for CLBP. In order to do this, a measure of adherence behaviour was developed and initially psychometrically evaluated (the EARS) (Study 2) (8.8.1.). Demographic and clinical variables were found to predict exercise adherence behaviour in Study 3, using the EARS to assess adherence behaviour (8.8.2.).

### 8.8.1. The EARS

In its present form, the EARS may provide a valid and reliable adjunct assessment of level of exercise adherence behaviour regarding specific features of exercise prescriptions (e.g. frequency, intensity, type and time of exercise) in individuals with CLBP. However, more information is required regarding the effectiveness of prescribed home exercise programmes on clinical outcome for CLBP. This would assist in identifying minimally important differences in order to evaluate improvement in adherence behaviour interventions. It is recommended that adherence behaviour is assessed using triangulation of measures. However, the development and psychometric evaluation of standardised measures of adherence behaviour is necessary to provide robust evaluation of adherence in future research. The EARS is considered a useful tool to assess exercise adherence behaviour where a more robust tool does not exist at the current time (Bollen et al., 2014; Hall & Fong, 2015). However, the EARS requires further psychometric evaluation to improve its psychometric standing.

Prior to further validation of the EARS, it would be necessary to amend the one ambiguous item (item 6 - ‘I do some, but not all, of my exercises’) to a similar, unambiguous item (e.g. to ‘I do most or all of my exercises’) (see Chapter 4, Section 4.4.2). Subsequent to this, the logical next steps in the development of the EARS include investigating sensitivity to change, plus additional

assessment of reliability and validity. Sensitivity to change is essential if the EARS is to be used to evaluate the effectiveness of interventions attempting to improve adherence behaviour. Criterion validity of the EARS may be investigated alongside objective activity devices where possible. This may best be done by investigation of specific types of prescribed exercise that can be reliably assessed by the objective activity monitor in question. Additionally, it would be advantageous to collect further data from the same CLBP sample that was used for the original validation of the EARS. Data from a larger CLBP sample would allow for reliable normative data to be obtained to aid the interpretation of scores from the EARS on a group level. Furthermore, reassessment of validity and reliability in the larger sample would help determine the validity of the original factor structure of the EARS. Moreover, assessment of sub-groups of patients that are expected to differ in terms of adherence behaviour may provide additional evidence of discriminant validity if the EARS can differentiate across sub-samples.

In addition to further psychometric evaluation for the EARS, items assessing reasons for adherence behaviour should be examined further. The ten reasons items were not found suitable for EFA in Study 2 (Chapter 5). However, this may be because reasons are formative indicators, rather than causal indicators, of a latent construct (Edwards & Bagozzi, 2000). This data may be explored using a formative construct approach with the aim of forming a valid scale assessing reasons for adherence behaviour that could be used alongside the EARS. A scale assessing reasons for adherence and non-adherence could provide useful data regarding specific areas of adherence behaviour where intervention may be required to improve clinical outcome in CLBP. After further psychometric evaluation, the EARS should provide a well-validated, reliable measure of exercise adherence behaviour for use in research and clinical settings. This, in turn, would add robustness to research findings in the exercise adherence literature, providing consistent information that may be used to inform the intervention and treatment of CLBP in the long-term.

### 8.8.2. Predictors of exercise adherence behaviour

The present research found that longer duration of pain, higher present pain, lower educational level and being female predicted poorer adherence to prescribed home exercise in a CLBP sample. This section considers the research and clinical implications of the results of Study 3. Clinical factors predicting adherence behaviour are discussed (8.8.2.1.). Subsequent to this, discussion focuses on the demographic factors that predicted adherence behaviour (8.8.2.2.).

#### 8.8.2.1. Research and clinical implications of clinical factors predicting adherence behaviour

Duration of pain and level of present pain were significant predictors of adherence behaviour in Study 3. These findings indicate that the two pain-related variables are important to include in future research investigating factors influencing and predicting exercise adherence in CLBP. However, this type of pain data is rarely included in main analyses of exercise adherence research with CLBP and MSK samples (see Section 8.5.1.). Research that does not include these factors may produce biased results, which, in turn, leads to less meaningful conclusions regarding predictors of adherence behaviour. For example, excluding duration of pain from regression analyses in the present research may have resulted in a different variable predicting adherence behaviour (e.g. anxiety) where that variable may not have predicted adherence once duration of pain was accounted for. The results would then indicate that anxiety plays a role in predicting adherence behaviour in CLBP, leading to future research that may disregard the role of duration of pain in favour of anxiety. For that reason, a key recommendation from the results of the present research is that duration of pain, along with present pain, are included in any analyses investigating adherence behaviour in a CLBP sample. A further reason to include multiple assessments of pain in main data analyses is that pain is undoubtedly a defining factor of any chronic pain condition and prescribed home exercise is the mainstay of treatment for CLBP. Therefore, it

should be beneficial to include data that provides information regarding the influence of pain on adherence to prescribed home exercise. The importance of high-quality research designs should be considered when planning future research, as many studies are cross-sectional, leading to problems elucidating directionality.

According to the findings of the present research, patients with CLBP who present with a long duration of pain and high self-reported present pain are less likely to adhere to prescribed home exercise recommendations. These patients could be referred to a psychology-based pain management programme if one is available prior to physiotherapy treatment. In addition to this, physiotherapists may use their knowledge and experience to decide how pain duration and level of pain play a role within consultation. For example, they might advise patients that pain levels do not necessarily equate to damage or harm and they may wish to discuss these barriers to exercise adherence in triage or the first treatment consultation. However, a comprehensive assessment is normally done in either triage or the first physiotherapy session and time may be limited. Further barriers to exercise adherence may be discovered throughout the first consultation and between consultations. Therefore, the physiotherapist may wish to use the second or third consultation to discuss relationships between clinical barriers to exercise adherence found in Study 3 (i.e. duration of pain and present pain) and other barriers that emerge during or between consultations.

Knowledge of the demographic factors that predicted poor adherence behaviour in Study 3 could also play an important role in predicting which patients with CLBP may be less adherent to prescribed home exercises. According to Study 3, a patient who is female, has a low level of education (i.e. no higher education qualifications), has a long duration of pain and a high level of present pain would be less adherent. A physiotherapist may be particularly cautious when prescribing home exercises for a patient such as this (e.g. prescribe fewer exercises and then increase this over time based on feedback from the patient or incorporate exercise into daily activities and household chores). Additionally, the physiotherapist may focus on barriers to exercise adherence early in the

consultation process and plan the treatment schedule accordingly (e.g. offer appointments in quick succession where possible or plan follow-up phone calls or emails to monitor adherence behaviour between appointments). Research and clinical implications of demographic factors predicting adherence behaviour in Study 3 are discussed further in the next section.

#### 8.8.2.2. Research and clinical implications of demographic factors predicting adherence behaviour

There is a paucity of research investigating level of education and its effects on exercise adherence behaviour in CLBP. Studies investigating exercise behaviour in healthy samples rarely assesses relationships between level of education and exercise behaviour (Bauman et al., 2012). Assessment of education including multiple variables (e.g. intelligence, social class, occupation and health literacy) would provide a more comprehensive evaluation than is available from Study 3 of the present research and related research literature discussed in this chapter. This, in turn, would provide a more detailed understanding of whether level of education, or related factors, predict unique variance in exercise adherence behaviour in CLBP. Based on the findings of Study 3, physiotherapists may ask patients about their level of education in order to understand how this might influence later adherence behaviour. However, information resulting from research determining which components of education are more likely to be related to adherence behaviour, would be clinically useful so that physiotherapists are prepared to probe for that information where it is acceptable to do so.

Findings that women are less likely to adhere to exercise were supported by current CLBP research (e.g. Mannion et al., 2009; Hügli et al., 2015) and exercise behaviour research in healthy samples (e.g. Department of Health, 2011; Townsend et al., 2015). Contributing further to these findings, Hügli and colleagues (2015) demonstrated that type of exercise moderates the role of gender in CLBP. This suggests that gender specific prescribed home exercises may play a role in improving adherence behaviour in women with CLBP. In

order for future research investigating the role of gender and type of exercise in CLBP to be clinically useful, research should also investigate further the effectiveness of different types of prescribed home exercise on clinical outcome in CLBP. The present research suggests that physiotherapists should consider that female patients with CLBP may be less adherent to prescribed home exercises. Since the reasons for this are unclear, physiotherapists may choose to focus on discussing barriers to exercise with female patients, rather than the other three non-modifiable factors that predicted poor adherence behaviour in Study 3. Furthermore, exercise programmes may have an individual component in one-to-one sessions regardless of gender. However, physiotherapists might consider a further effort to individualise exercise programmes for women that are tailored based on preferences and value-based goals (McCracken & Yang, 2006).

Future research should use prospective and longitudinal designs with regular follow-up to provide a better understanding of causal relationships between assessed factors and the initiation and maintenance of exercise behaviour over time. This is particularly important for a long-term condition, such as CLBP, where periods of exacerbation and remission are common (Medina-Mirapeix et al., 2009). Furthermore, qualitative research should follow the initial development of novel CLBP interventions to assess their acceptability and feasibility. This would allow for necessary modifications to be made prior to investigations of larger samples, as recommended by Medical Research Council (MRC) guidance for developing and evaluation complex interventions (Craig et al., 2008).

Theory-based interventions investigating adherence to exercise in CLBP are necessary to provide a greater understanding of behaviour change so that findings can more easily be translated into clinical practice (Lonsdale et al., 2012). However, in order to provide specific information regarding processes of behaviour change, the use of a taxonomy of behaviour change techniques is suggested (Davis, Campbell, Hildon, Hobbs, & Michie, 2014; Michie et al.,

2011). The capability (C), opportunity (O) and motivation (M) model of behaviour (B) (COM-B) is a model of behaviour change techniques that has been used to explain which components of behaviour change interventions bring about change in medication adherence behaviour (Jackson et al., 2014). This model may be a useful tool to use in the development of exercise adherence behaviour interventions as researchers can easily see which factors have already been found to influence adherence, and where there may be gaps in the research that require further investigation. This would be a positive first step towards gaining a collective and common knowledge regarding components of interventions that have been shown to improve exercise adherence behaviour. Furthermore, the use of a taxonomy should allow for improvement in effectiveness of interventions due to more straightforward replicability of research studies (Michie et al., 2011). This, in turn, will provide information about processes of change that allow for effective dissemination of findings regarding implementation into clinical practice.

## 8.9. Conclusions

This thesis has addressed gaps in the CLBP research literature by conducting three studies. Firstly, factors that influence adherence to prescribed home exercise in CLBP were systematically reviewed (Study 1, Chapter 3). This systematic review is the only published review to the author's knowledge that has provided a rigorous examination of existing research in this area. Secondly, the first measure of adherence to prescribed exercise in CLBP was developed and psychometrically evaluated (the EARS) (Study 2, Chapter 4). The EARS has provided a simple, standardised, reliable assessment of adherence to prescribed home exercise in CLBP. Thirdly, a study was conducted to investigate factors predicting prescribed home exercise in a CLBP sample (Study 3, Chapters 5-7). Four factors were identified that predicted poorer exercise adherence behaviour in CLBP. These factors were longer duration of pain, higher present pain, lower educational level and being female.

Findings from CLBP and MSK research literature investigating adherence behaviour led to the expectation that psychosocial factors would play a larger role in predicting exercise adherence behaviour in Study 3 (Chapters 5-7). However, the findings from Study 3 demonstrate the necessity for further research to provide additional information regarding factors associated with adherence to prescribed home exercise in CLBP. Better understanding of these factors is required in order to develop effective interventions that encourage long-term self-management in CLBP.

Current health behaviour theories and models require expansion to include demographic and clinical factors that have been found to predict adherence behaviour in the present research and recent CLBP research (e.g. Hügli et al., 2015). Inclusion of demographic and clinical factors into health behaviour models and theories would provide a more inclusive theoretical underpinning than is presently available to explain exercise behaviour in CLBP. A model of behaviour change (i.e. the COM-B model) is suggested as a valuable tool to effectively integrate current and future findings into a useable framework to benefit research and clinical practice (Michie et al., 2011; Davis et al., 2014).

Findings from Study 3 regarding deficits of behavioural inhibition/mental flexibility and planning ability in a CLBP sample has extended the current research base that has found different executive function deficits in individuals with CLBP. These deficits were not predictive of exercise adherence behaviour in the present study. However, this was the first study to investigate relationships between executive function deficits and exercise adherence behaviour and some limitations of this study have already been discussed. Further research is therefore required to investigate the possible effects of executive functions on exercise adherence behaviour in CLBP. Seminal research that has found CBT to improve neuropsychological status and executive functions (i.e. Shpaner et al., 2014). This may provide a promising foundation from which to investigate ameliorating executive function deficits in CLBP. Furthermore, the recently updated TST model provides a plausible

theoretical basis for future investigation of executive functions and exercise behaviour in CLBP. Clearly, more research is warranted to assess further the effects of executive function deficits on adherence to prescribed home exercise in CLBP.

CLBP remains a costly and challenging condition for individual, the NHS, and society at large (NICE, 2009). With the role of exercise widely recognised as necessary for both primary prevention, secondary prevention and the treatment of chronic illness, it is important that adherence to prescribed home exercise can be adequately assessed. Comprehensive definitions of exercise adherence behaviour are necessary to assist the scoring and interpretation of measures assessing adherence behaviour. This, in turn, will allow for more robust assessment of exercise adherence behaviour. Additionally, reliable and valid assessment of adherence behaviour may facilitate the development and evaluation of interventions that encourage long-term self-management for both the prevention and treatment of CLBP. It is likely true that the practical and effective assessment and treatment of exercise adherence behaviour will have major implications for the treatment of CLBP in the future. This thesis represents an important contribution to the development of this under researched area.

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## Appendix 1. Patient Information Sheet

**Guy's and St Thomas' NHS Foundation Trust**

**REC study number: 10/H0808/9**

**PATIENT INFORMATION SHEET**

**Executive function, beliefs and adherence to pain exercises**

**Introduction**
You are being invited to take part in the above research study. Please take time to read the following information carefully and discuss it with friends, relatives or your doctor if you wish. Please ask us if there is anything that is not clear or if you need more information. Thank you for reading this.

**What is the purpose of the study?**
Every year, 38% of the adult British population experiences a significant episode of low back pain. 75% of these people will still have some pain and disability after several weeks and may be referred to physiotherapy, where active management including exercise has become the mainstay of treatment. The purpose of this study is to explore how people with back pain view the exercises that have been recommended for them by their Physiotherapist. We know that patients differ in their opinions about the value of these exercises and would like to find out more about the factors which influence their beliefs and motivations to do the exercises. This study is being carried out by a student as part of a PhD programme in back pain and Physiotherapy.

**Why have I been chosen?**
You have been chosen because you have been referred to physiotherapy at Guy's, St Thomas' or King's College Hospital with back pain. 100 people referred for physiotherapy will be asked to participate in the study. They will complete 6 brief questionnaires before their course of physiotherapy, and 3 short questionnaires over the phone after their course of physiotherapy.

**Do I have to take part?**
It is up to you to decide whether or not to take part and taking part in this research is entirely voluntary. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form (you will also be given a copy of the consent form to keep). If you do decide to take part you are still free to withdraw from the study at any time without giving a reason. This will not affect the treatment you receive in any way. All answers you give will be anonymous and confidential and you will not be identified in any way by your responses.

**What will happen to me if I take part and what study procedures and tests will be involved?**
When you come to the Physiotherapy Department, we will ask you to take part in one of two sets of tests.

If you are given the first set of tests, you will be asked to fill in 6 brief questionnaires and to complete 4 verbal or paper and pencil tests of cognition and memory. These are all brief and should take between 45 and 60 minutes in total to complete. The results from the questionnaires and tests will be analysed to investigate the reasons for the different beliefs patients with back problems hold about their exercises, and how this influences the way they do their exercises. This is the only time you will need to see a researcher, however patients doing the first set of tests will be contacted 3 months after this date to fill in 3 short questionnaires so

we can see what changes have occurred since starting physiotherapy treatment. This should take no more than 10 minutes.

If you are given the second set of tests, you will be asked to complete a consent form and a demographics form at the beginning of your physiotherapy treatment. At the end of treatment, you will be asked to complete a questionnaire about the exercises you were asked to do as part of your treatment. This will take no longer than 10 minutes. You will also be asked if you are willing to be contacted 3 weeks after this to complete the exercise questionnaire a second time.

**How will happen to the information collected?**
All information collected about you during the course of the research will be kept strictly confidential e.g. in a locked filing cabinet and stored on a dedicated computer. Any information about you which leaves the hospital will have your name and address removed so that you cannot be recognised from it. The results of the study will be published in medical journals and presented at medical conferences. Copies of the results can be obtained from the study organiser (Dr Emma Godfrey) when the study is completed.

**What are the possible disadvantages and risks of taking part?**
This is a very low risk study. The disadvantage is the time spent completing the tests and questionnaires. These should not take more than 30 minutes in total to complete.

**What are the possible benefits of taking part?**
We cannot promise the study will help you but the information we get will help improve the treatment of people with back pain.

**What if there is a problem?**
If you have a concern about any aspect of this study, you should ask to speak with the researchers who will do their best to answer your questions (020 7188 0180). Any complaint about the way you have been dealt with during the study or any possible harm you might suffer will be addressed. If you remain unhappy and wish to complain formally, you can do this through the NHS Complaints Procedure. Details can be obtained from the hospital.

**What will happen if I don't want to carry on with the study?**
You can withdraw from the study at any time without affecting your treatment in any way.

**Will my taking part in this study be kept confidential?**
Yes. We will follow ethical and legal practice and all information collected about you during the course of the research will be kept strictly confidential and anonymous.

**Who is sponsoring the study?**
King's College London and Guys & St Thomas's Foundation NHS Trust

**Who has reviewed the study?**
This study has been reviewed by the King's College Hospital Research Ethics Proportionate Review Sub-Committee

Thank you for reading this information sheet

## Appendix 2. Data Extraction Table for Study 1

**Study: Donzelli et al. (2006) Two different techniques in the rehabilitation treatment of low back pain: a randomized controlled trial.**

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| **Population** | N = 53; final N = 43 | Milan, Italy; age 20 – 65 (mean age stated for entire sample only = 50.08, SD not stated); percentage of men and women not provided. Participants had CLBP for at least 3 months. Exact duration of pain was not stated. |
| **Intervention** | Experimental group | N = 21; Pilates CovaTech therapy in groups of up to 7 people for 10 hour long sessions. |
| | Control | N = 22; Back school in groups of up to 7 people for 10 hour long sessions. |
| | Treatment delivery | A rehabilitation therapist trained in either Pilates CovaTech therapy (P) or the Back School method (B). The therapist for each group was different. |
| | Procedure | Patients were divided into groups based on choice of time session. After the 10 sessions, patients in both groups were given booklets to aid them in continuing their exercises at home. The authors did not define adherence to exercise, and did not state how often patients were asked to exercise at home. |
| | Is adherence a primary outcome?* | Yes. Mentioned in abstract. |
| | Adherence to home exercise measures | Patients were asked whether, and how often, they had managed to do their exercises at home. No standardised measure was used. |
| | Other outcome measures | i. Disability - Oswestry Low Back Pain Disability Scale (Italian version) (Fairbank et al., 1980)<br>ii. Back pain - 10cm VAS.<br>iii. Patients were asked to state level of satisfaction and benefit gained from treatment.<br><br>All measures were taken at baseline, 1, 3 and 6 months. At 6 months patients were asked about relapse and absence |

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| | from work, and if they had sought advice from other specialists. |
| Data analysis | The authors used descriptive statistics to explore mean values of pain and disability over time, and percentage of adherence in the Pilates versus the control group. No inferential statistics were provided. |
| Treatment outcomes (adherence) | The authors stated that the Pilates group were more adherent. However, the results showed that 45.45% of the B (10), and 28.57% (6) of the P group did their exercises at home. 4.5% (1) of the B group and 9.5% (2) of the P group reported doing their exercises on a regular basis. This shows that the P group may have been more adherent to exercising on a regular basis; however the B group were more likely to exercise at home, even if they exercised less regularly. |
| Treatment outcomes (other) | Mean reduction in pain and disability was stated as similar in both groups (numeric data not stated).<br>i. Satisfaction in the P group - very satisfied 61.9%; B group - satisfied 77.27%.<br>ii. Perceived benefit gained in P group – 14.3%; and in B group 22.7%.<br>iii. Little benefit gained in P group – 14.3%; and in B group 31.8%. |
| Relationship between level of adherence and outcome (if explored) | Not explored. |
| Baseline predictors of adherence (if explored) | Not explored. |
| Key adherence conclusions of study authors | The authors stated that the Pilates group were more adherent to home exercise than the back class group. |
| Correspondence | The authors were contacted via email and asked to explain the meaning of "improvements of symptoms" from the journal article. It was unclear if improvements included pain and disability. However, the authors explained that improvements were related to “a general subjective feeling of improvement”. |

**Study: Ljunggren et al. (1997) Effect of exercise on sick leave due to low back pain: a randomized, comparative, long-term study.**

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| **Population** | N = 153<br><br>Final N = 126 (End of 12 month supervised period)<br><br>Final N = 103 = (End of 12 month unsupervised period) | Norway; age 18 – 65; mean age stated for intervention group = 39 (SD 10.4) and for control group = 40.2 (SD 9.5). Patients must have had a history of back problems. All patients had finished a programme of physiotherapy treatment for their back pain before participation in this study. No definition of back pain in terms of chronicity, however 88% of the experimental group, and 68% of the control group, had been on sick leave from work with back pain within the past 12 months. Exact duration of pain was not stated. |
| **Intervention** | | |
| | Experimental group | N = 62. TerapiMaster programme. 9 basic exercises were carried out in 3 series of 10 repetitions, 3 times a week. To promote adherence, 8 follow-ups were carried out by the physiotherapist during the course of the study (approximately every 6 weeks); contact was made 8 times. Then unsupervised for 12 months. |
| | Control | N = 64. Physiotherapist designed conventional exercise programme. Nine basic exercises were carried out in 3 series of 10 repetitions three times a week. Same as above. |
| | Treatment delivery | Patient saw same physiotherapist that they had seen prior to inclusion into the study. |
| | Procedure | The study was carried out as an open, randomized, multicenter, parallel-group study with an observation period of 12 months. Patients were seen after a previous course of physiotherapy treatment for their back pain. They were randomly allocated into either the experimental or control group. Both groups were supervised for 12 months of home exercise, and were then unsupervised for an additional 12 months. Adherence was based on the patients being asked to exercise at home for 15 to 30 minutes, 3 times each week. |
| | Is adherence a primary | Yes. Mentioned in abstract. |

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| outcome?* | |
| Adherence to home exercise measures | At each follow-up, patients were asked how often, and for how long, they exercised each week. No standardised measure was used. |
| Other outcome measures | i. Satisfaction with programme - 10cm VAS.<br>ii. Absenteeism from work during the training period. |
| Data analysis | A one-sided Wilcoxon rank-sum test with adjustments for ties was used in the statistical analysis of the number of variable sick leave days. A one-sided log-rank test was used in the statistical analysis of the variable time until a new episode. A significance level of 5% was used. The authors used descriptive statistics, but no inferential statistics, to explore adherence. |
| Treatment outcomes (adherence) | Supervision was found to influence better adherence. 33% patients in the intervention group (home exercise using specialised equipment) and 35% of patients in the control group (standard PT) reduced home exercise at the end of a 12 month unsupervised period, prior to which they had participated in 12 months of supervised exercise. |
| Treatment outcomes (other) | Mean (SD) VAS satisfaction rating:<br>i. During supervised practice: Conventional = 7.7 (1.8); TerapiMaster 7.7 (1.8)<br>ii. During Unsupervised follow-up: Conventional = 5.7 (1.3); TerapiMaster 5.6 (1.3)<br>iii. NSD between groups in satisfaction with exercise programme<br><br>Work absenteeism (number of days):<br>i. During supervised practice: Conventional = 17.2 (6.0); TerapiMaster 15.4 (5.3)<br>ii. During Unsupervised follow-up: Conventional = 9.9 (3.2); TerapiMaster 9.3 (3.1)<br>iii. Work absenteeism: NSD between groups prior to commencing therapy; reduction over time reported not between groups post-therapy. |
| Relationship between level of adherence and | Not explored. |

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| | outcome (if explored) | |
| | Baseline predictors of adherence. | Not explored. |
| | Key adherence conclusions of study authors | Adherence with exercise programmes is reduced when the patients are unsupervised. Regular follow-up through encouragement and variation in the training programmes appear to be important factors for motivating patients to adhere to regular exercise programmes for low back problems. |
| | Correspondence | Authors were non-contactable via phone or email. |

**Study: Friedrich et al. (1998) Combined exercise and motivation programme: effect on the adherence and level of disability of patients with chronic low back pain: a randomized controlled trial.**
**Friedrich et al. (2005) Long-term effect of a combined exercise and motivational programme on the level of disability of patients with chronic low back pain.**
Both studies from same cohort.

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| **Population** | N = 93 | Vienna, Austria. 46 men, 57 women. Mean age stated for entire sample only = 44 years (SD 10.66) (20 – 60 years) |
| | Final N = 56 | Patients had back pain for at least 4 months, or 3 episodes of pain in past 6 months, with current episode lasting at least 2 months. Mean duration of pain was stated for the intervention group in months = 50.64 (SD 49.18) (4.22 years (SD 4.09) and for the control group = 46.1 (SD 43.84) (3.8 years (SD 3.65). |
| **Intervention** | | |
| | Experimental group | N = 44. Motivation and exercise (M & E) group. Exercise and advice, plus motivation programme consisting of 5 interventions: 1) counselling emphasising importance of regular exercise inc. barriers; 2) positive reinforcement techniques; 3) treatment contract between physiotherapist and patient; 4) put contract up at home; 5) maintain an exercise diary. |

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| Control | N = 49. (E group). Individualised, graded exercise programme and advice. |
| Treatment delivery | 8 physiotherapists. |
| Procedure | Patients had 10 exercise sessions. Adherence was based on the following: from the first session, they were advised to exercise at home, daily if possible, and to continue exercising after the end of treatment. |
| Is adherence a primary outcome? | No, although mentioned in abstract (1998). However, authors (1998) state in the statistical analysis section, and in the abstract (2005), that pain, disability and physical impairment are the main outcomes. |
| Adherence to home exercise measures | Training frequency and duration at 4 month, 1 year and 5 year follow-up – asked by physiotherapist. No standardised measure of adherence was used. In addition, the M & E group used daily exercise diary. |
| Other outcome measures | Number of treatment sessions attended.<br>i. Disability - Greenough and Fraser disability questionnaire (Greenough and Fraser, 1992)<br>ii. Pain (101 numerical rating scale)<br>iii. Motivation- Psychotherapy Motivation Questionnaire (baseline, 8m and 1 year) |
| Data analysis | Descriptive and inferential statistics were used. Comparison of the 2 groups was performed with the Chi-square test, Student t test for independent means, or Mann-Whitney U test. Differences between the various points of assessments were analyzed using the Student t test for dependent means or the Wilcoxon matched pairs signed rank test. |
| Treatment outcomes (adherence) | There was NSD in 4 month and 5 year adherence to home exercise between the 2 groups. Participation in a motivational programme was found to influence better adherence at 12 months. At 12 months, weekly training frequency in the M & E group was significantly higher than in the standard (E) training group. (U = 396.5, *P* = 0.036) |
| Treatment outcomes (other) | i. The M & E group were significantly more consistent in attending exercise sessions (M & E mean attendance = 9.6 sessions; E = 8.6; p. = 0.0005). 81.8% of patients in the M & E group attended all 10 sessions, compared to 51% of the control group.<br>ii. Disability was significantly reduced in the M & E group at 12 months and 5 years (p = 0.003).<br>iii. Pain intensity increased significantly in the M & E group, but not in the E group (5 years – p <0.001). |

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| | | iv. Working ability was significantly better in the M & E group at 5 years (p = 0.005). |
| | Relationship between level of adherence and outcome (if explored) | Yes, in their 1998 paper. Significant correlations were found between adherence and motivation sub-scales:<br>Higher distress at 3.5 weeks, the longer total training time at 4m and 1 year (r =.182, p = .036).<br>Higher level of internal control at 3.5 weeks, longer total training time at 4months (r = .244, p = .043).<br>No correlation between disability and adherence. No mention of level of pain and adherence. |
| | Baseline predictors of adherence (if explored) | None. |
| | Key adherence conclusions of study authors | Although the combined exercise and motivational programme reduced disability and pain levels, there was no evidence of cause and effect between improved motivation, increased adherence, and superior treatment outcome in terms of disability, pain intensity, and working ability. Adherence is not necessarily associated with clinical outcome. |
| | Correspondence | None. |

**Study: Harkapaa et al. (1991) Health locus of control beliefs and psychological distress as predictors for treatment outcome in low-back pain patients: results of a 3-month follow-up of a controlled intervention study.**

| | | |
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| **Population**<br>**Intervention** | N = 476; Final N = 459 | Aged 35-54 years; mean age stated for entire sample only = 45 years (SD not stated); 63% men. Finland. Patients all had chronic back pain (> 3 months). Mean duration of pain for outpatient group = 14.6 years (SD not stated) and for control group = 13.4 years (No SD stated). |
| | Experimental group 1 | Inpatient N = 156. Data from the inpatient group was not included in this review. |
| | Experimental group 2 | Outpatient N= 150. 15-session back treatment programme (2 hour sessions held twice a week) either at work or at the local health centre. |

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| Control | Control N= 153. The control group received written and oral instructions on back exercises and ergonomics at the beginning of the study. |
| Treatment delivery | Treatment led by a physiotherapist. |
| Procedure | The experimental programme consisted of a Swedish back school (4 sessions), back exercises (15 sessions), relaxation exercises (9 sessions), and 3 group discussions (2 by a psychologist on coping with chronic pain, and 1 by a physician on aetiology and treatment of LBP). Patients were given heat or electrotherapy prior to back exercise sessions. All treated subjects were taught a back exercise programme to be carried out after treatment. Follow-up was at 3 months.<br>Adherence was based on the following: a criterion for good accomplishment, at least 3 faultlessly demonstrated exercises were required (0 = 0-2 exercises; 1 = 3 exercises). Practice of back exercises at least 4 times/week was regarded as an indicator of regular exercising (0 = 0-3 times/week; 1 = 4-7 times/week). |
| Is adherence a primary outcome? | Yes. Adherence discussed in abstract. |
| Adherence to home exercise measures | Adherence was assessed at the 3-month follow-up by the physiatrist who checked the number of faultless exercises the patient could demonstrate, range O-3, and exercise frequency (times/week) during the follow-up period. No standardised measure was used. |
| Other outcome measures | i. Disability - LBP disability index (Jacobson et al., 1984).<br>ii. Health locus of control beliefs - 11-item HLC scale together with 2 items measuring beliefs in back pain control. (Wallston et al., 1976).<br>iii. Psychological distress - 12-item General Health Questionnaire (GHQ-12) (Banks et al., 1980) |
| Data analysis | Changed in disability and differences between groups was tested using a 2-way ANOVA. Stepwise logistic regression were applied using successful outcome (0 = no gain; 1 = gain) (based on changes in disability), and the accomplishment and frequency of exercises as dependent variables. Differences between study groups in successful outcome and adherence were calculated with chi-square. |
| Treatment outcomes | i. Patients with a stronger belief in their internal control over their back pain, exercised significantly more than |

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| (adherence) | those with a weaker belief in their internal control at 3 month follow-up (OR = 1.96, *P* < 0.000).<br>ii. Patients with a stronger belief that others have control over their back pain exercised significantly less than those with a weaker belief at 3 month follow-up (OR = 0.75, *P* < 0.013).<br>iii. Patients with lower distress levels demonstrated a significantly higher number of back exercises faultlessly at 3 month follow-up (OR = 0.53, *P* < 0.009).<br>iv. Patients with higher disability levels at baseline exercised more at 3 month follow-up compared to those with lower baseline disability levels (OR = 1.04, *P* < 0.031).<br>v. Participation in a back school, incorporating psychology and education, was found to influence better adherence. Patients in the intervention group exercised more frequently (OR = 0.51, *P* < 0.037) and showed better accomplishment of back exercises (OR = 0.16, *P* < 0.000) at 3 month follow-up (versus control group with written and oral instructions to exercise). |
| Treatment outcomes (other) | i. There was a significantly greater decrease in disability in the outpatient group compared to the control group (F (1, 301) = 7.30, P < 0.01).<br>ii. LBP – NSD between outpatients and controls ($\chi^2$ (1) = 1.41, *P* = not provided). |
| Relationship between level of adherence and outcome (if explored) | Those with more severe disability gained more from the intervention and practiced back exercises more often than those with less disability. Stronger belief in internal back pain control was associated with a higher frequency of exercise. Also, a stronger belief in control by others was associated with lower frequency of back exercise during the follow-up period. Psychological distress was significantly associated with the accomplishment of exercise: those with distress could demonstrate a smaller number of back exercises faultlessly at the follow-up. See above for reported statistics. |
| Baseline predictors of adherence (if explored) | HLC, psychological distress, and higher disability at baseline, were found to influence adherence to home exercise. See above for reported statistics. |
| Key adherence conclusions of study authors | Stronger belief in personal control over back pain was significantly associated with more frequent exercising. The significant association between the accomplishment of back exercise and symptoms of psychological distress seems to indicate that the effects of distress may manifest during the learning process. |
| Correspondence | The authors were contacted via email to ask about the chronicity of the patients involved in the study. The authors |

stated that only subjects with CLBP (>3 months) were included.

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**Study: Soukup et al. (2001) Exercises and education as secondary prevention for recurrent low back pain (3 year follow-up).**
**Soukup et al. (1999) - The effect of a Mensendieck exercise programme as secondary prophylaxis for recurrent low back pain: A randomized, controlled trial with twelve month follow-up.**
Both studies from same cohort.

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| **Population** | N = 77<br>Baseline = 69 (1999);<br>Final N = 67 (2001) | Oslo, Norway. 41 women and 36 men; 18 – 50 years; mean age for experimental group = 40.3 years (CI 37.6 – 42.9) and for control group = 38.9 (CI 36.6 – 41.2). . Patients all had chronic back pain (> 3 months). Mean duration of pain for experimental group = 4735 days (13 years) (CI 3595 - 5874) and for control group = 4084 days (11.1 years) (CI 3289 - 4880). Patients had finished treatment for their last episode of LBP before inclusion in the study. |
| **Intervention** | | |
| | Experimental group | N = 39. Mensendieck exercise programme. Designed as a secondary prevention programme for people with LBP. Consists of 20 sessions of exercises and biomechanical / ergonomic education over 13 weeks. |
| | Control | N = 38. Written and oral information about the Mensendiek approach as a secondary prevention programme. No treatment was offered, but patients were free to receive treatment or exercises. |
| | Treatment delivery | Mensendieck-educated physiotherapist. |
| | Procedure | Participants were randomly allocated to group in blocks of 6 to maintain a consistent class size. Mensendieck training program lasted 13 weeks. The participants also received written info regarding simple exercises and advice for back care during daily activities. All participants were assessed at 5-month and 12-month follow-up. Adherence was based on following advice to perform regular physical training during free time. |
| | Is adherence a primary outcome? | No. |

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| Adherence to home exercise measures | Frequency of participation in group sessions and frequency of participation in regular leisure physical training (at least one 30 minute exercise period per week). |
| Other outcome measures | i. Pain – VAS 100mm<br>ii. Function: VAS (100mm)<br>iii. General Functional Status - Dartmouth COOP Functional Assessment Charts (Bentsen et al., 1997). |
| Data analysis | Comparisons between groups on continuously distributed variables were performed by using an ANOVA. Changes within groups were assessed by repeated measures ANOVA. A significance level of 5% was used. |
| Treatment outcomes (adherence) | Participation in a Mensendieck exercise programme, including an educational component, was found to increase adherence. Patients in the intervention (Mensendieck) group did significantly more home exercise at 12 month follow-up compared to their baseline levels of exercise ($P < 0.05$). Exercise levels in the control group (written and oral information) remained static from baseline to 12 month follow-up. The number of participants in the Mensendieck group performing regular leisure physical training rose from 17 (50%) at baseline to 26 (76%) after 12 months. This compared to 26 (76%) participants in the Control group at baseline and 28 (80%) after 12 months. There was NSD between groups at 12 month or 3 year follow-up in the amount of leisure-time physical activity. |
| Treatment outcomes (other) | i. Reduction in pain episodes in Mensendieck group, with 11 (32%) participants experiencing recurrent episodes compared with 20 (57%) in the control group ($p<0.05$).<br>ii. Significant reduction at 12 month follow-up in pain severity related to exercise and working in the Mensendieck group compared with control ($p<0.01$). NSD between groups in overall pain severity.<br>iii. Trend towards reduction in absenteeism in Mensendieck group but NSD when compared with control.<br>iv. Improvement in functioning for both groups (NSD between groups post intervention). |
| Relationship between level of adherence and outcome (if explored) | No. |
| Baseline predictors of adherence (if explored) | Not explored. |

| | | |
|---|---|---|
| | Key adherence conclusions of study authors | NSD between the groups in reports of regular exercise habits after 3 years. |
| | Correspondence | The authors were contacted via email to find out about the chronicity of the patient group. The authors confirmed that the patients had CLBP (>3months). |

**Study: Kuukkanen et al. (2007) Effectiveness of a home exercise programme in low back pain: a randomized five-year follow-up study.**

| | | |
|---|---|---|
| **Population** | N = 60; final N = 57 | Jyväskylä, Finland; 31 – 49 years; mean age of control group = 40 years (± SD 8.9); mean age of experimental group = 41 years (± SD 8.1); 28 males and 29 females. Patients had CLBP for at least 3 years. Mean duration of pain for experimental group = 11.1 years (± SD 8.8) and for control group = 10 years (± SD 7.7). |
| **Intervention** | | |
| | Experimental group | N = 29. 3 months of home exercise using 3 progressive monthly programmes. Progression of programme was based on independently done weekly tests. A physiotherapist supervised once a month in an exercise room. |
| | Control | N = 28. The control group were a no-treatment control. |
| | Treatment delivery | Physiotherapist. |
| | Procedure | The 3 month home exercise programme, which was presented in a written and illustrated form, consisted of three progressive monthly programmes. The progression of the programme was based on weekly tests, which the home exercise group performed independently. A physiotherapist supervised the exercise programmes once a month in an exercise room. Both groups were assessed at 3, 6, 12 months, and 5 years. In the experimental group, patients were encouraged to continue back specific exercises and maintain a physically active life. Adherence was based on the attempt to exercise every day and record this in their diaries. |

| | |
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| Is adherence a primary outcome? | No, however a comparison of general physical activity (PA) between both groups was mentioned in the abstract. |
| Adherence to home exercise measures | i. Diary to record daily exercise (in intervention group).<br>ii. Exercise frequency and total exercise time for one session, during 1 month, and during 3 months.<br>iii. General physical activity in both groups over the 5 years (inc. work, commuting and leisure time.) |
| Other outcome measures | i. Pain - Borg CR-10 (Borg, 1998).<br>ii. Disability – Oswestry Disability Index (Fairbank et al., 1980). |
| Data analysis | The differences between non-parametric variables were studied with chi-square tests, and those between parametric variables with Student's t-tests and analysis of co-variance (ANCOVA). Median regression analysis and Hodges–Lehmann estimates for the difference between study groups were used. A significance level of 5% was used. |
| Treatment outcomes (adherence) | Participation in a home exercise programme was found to influence adherence at 1, 2, and 3 month follow-up. This paper only explored adherence to back exercises in the intervention group. Patients in the intervention group (home exercise programme) exercised an average of 3.5 sessions per week, for 49, 47, and 44 minutes per session, at 1 month, 2 month, and 3 month follow-up respectively. No inferential statistics were provided for this data. Overall PA decreased slightly in both groups over 5 years, but there was NSD between groups. |
| Treatment outcomes (other) | The CR-10 and ODI scores decreased during the first three months in both study groups. During the follow-ups, the corresponding indicators of the home exercise group remained below baseline values. The CR-10 score was significantly lower in the home exercise group ($p = 0.01$) during the last five-year follow-up session compared with the control group. |
| Relationship between level of adherence and outcome (if explored) | No. |
| Baseline predictors of | Not explored. |

| | | |
|---|---|---|
| | adherence (if explored) | |
| | Key adherence conclusions of study authors | Overall PA in both groups decreased slightly at 5 years, but there was no difference in PA between both groups at 5 year follow-up. Author added to back exercises adherence at 5 years – see below. |
| | Correspondence | Authors were contacted via email to confirm that the control group were a no-treatment control. |

**Study: Linton et al. (1996) Exercise for workers with musculoskeletal pain: does enhancing adherence decrease pain?**

| | | |
|---|---|---|
| **Population** | N = 48; final N = 48 | Orebro, Sweden; Mean age = 42 years; (age range or SD not stated); 20 females. Must have had back pain in the last year. Author contact confirmed that participants had CLBP (>3 months). Pain duration was not stated. |
| **Intervention** | Experimental group | Exercise Compliance Enhancement (N = 25): individualised cognitive-behavioural sessions concentrating on developing an activity program specific to each participant. (SMART goal planning). |
| | Control | Work Place Exercise Campaign (N = 23): Exercise recommendations and free membership to health centre where participants could perform PA with professional assistance. |
| | Treatment delivery | Behavioural Psychologist (experimental group only). |
| | Procedure | Participants were randomly allocated to either group. Those in the control group were given access to exercise facilities but no structured input. Those in the experimental group met with the psychologist to plan their activity and how they would meet potential challenges. Those in the experimental group had 7 further contacts via telephone or in person (average total contact time was 2 and a half hours per person) with the psychologist over the course of the study. Participants were advised to exercise for at least two 20 minute sessions each week at an intensity that would increase their respiration and heart rate. Adherence was based on duration and intensity of this exercise. |

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| Is adherence a primary outcome? | Yes, in title and abstract. |
| Adherence to home exercise measures | Participants were asked to complete 5, 1 week activity diaries over 1 month intervals (covering a 6-month period). Diaries contained information regarding frequency, type, duration and intensity of activity; 88% of diaries were completed returned for analyses. |
| Other outcome measures | i. Pain – VAS (0 – 10)<br>ii. Well-being – authors don't state measure used; only that well-being was measured.<br>iii. Aerobic capacity – cycle test.<br><br>In addition, at the 6 month post-test, participants were asked if their exercising had increased, if it was more enjoyable, and if they experienced as much pain when physically active as compared to the previous year. These ratings were made on a 5-point scale (1 = substantial decrease 2 = decrease, 3 = about the same, 4 = increase, 5 = substantial increase). |
| Data analysis | Diary data were summarised for each weekly period: Adherence participants exercised to increase heart rate at least 2 x a week. MANOVA (multivariate analysis of variance) was used to compare assessments for all 5 periods on the number of strenuous activities that fulfilled the criteria for adherence. Post-hoc tests were carried out to compare adherers and non-adherers (across the two groups). |
| Treatment outcomes (adherence) | Participation in a behaviour change programme was found to influence better adherence. Patients in the intervention group (behavioural programme plus advice to exercise) did significantly more strenuous exercise than the control group (advice to exercise) at 3 months ($t = 1.89$; $P = .033$); 5 months ($t = 2.41$; $P < .01$); and overall ($t = 2.10$; $P < =.03$). The intervention group also took part in significantly more general exercise activities at 6 months ($t = 2.78$; $p < .005$).<br><br>Adherers across both group participated in over 3 times more activities than non-adherers during the 6 month course of the study and this difference was significant ($t = 6.33$; $p < .0001$). |
| Treatment outcomes (other) | No significant between-groups difference for physical condition<br><br>Pain intensity was exacerbated for both groups by exercise ($t = 4.60$, $p<0.001$), there was no significant difference |

| | | |
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| | | between groups. |
| | Relationship between level of adherence and outcome (if explored) | This study explored whether adherence to exercise led to a decrease in pain. Pain decreased in both groups, but the effect of PA on overall pain was not significantly different between groups. Adherence did not have a significant effect on pain. The authors also compared adherers (N=22) and non-adherers (N=20) across both groups. Aerobic capacity increased for compliers but slightly decreased for non-compliers ($t = 2.96$, $p<0.005$). Long-term effects: at the end of the study not only did adherers report greater exercise participation but reported greater enjoyment than non-adherers ($t = 1.89$, $p <0.04$).<br>Adheres rated significantly less pain in relation to activities as compared to the previous year than did non-adherers ($t = 2.18$; $p<0.02$). |
| | Baseline predictors of adherence (if explored) | Not explored. |
| | Key adherence conclusions of study authors | This study does not support the idea that exercise reduces pain for people with moderate pain problems and no habit of previously exercising. The increase in adherence noted in this study appears to be of clinical relevance. More than 50% of the intervention group adhered to the exercise regimen, and even those not fulfilling the adherence criteria increased their level of exercising. |
| | Correspondence | Contact with authors via email to confirm that all participants had CLBP for > 3 months. |

**Study: Reilly et al. (1989) Differences between a supervised and independent strength and conditioning programme with low back syndromes.**

| | | |
|---|---|---|
| **Population** | N = 40; final N = 40 | Denver, USA. Men and woman; age not stated, except to say that both groups were age matched. Patients all had CLBP; however chronic back pain was not defined. Duration of pain was not stated. |
| **Intervention** | Experimental group | N = 20. Supervised exercise. Given pre-designed exercise programme and told to exercise 4 x a week for 6 months, but monitored by a strength and mobility specialist at each session = 96 sessions. |

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| Control | N = 20. Independent exercise. Given pre-designed exercise programme and told to exercise 4 x a week for 6 months = 96 sessions. |
| Treatment delivery | Strength and mobility specialist. |
| Procedure | Subjects were told of 3 comparable health clubs they could attend, and staff assessed adherence. Adherence was based on the number of exercise sessions participants did per week. Follow-up was at 6 months. |
| Is adherence a primary outcome? | Yes, in abstract. |
| Adherence to home exercise measures | Staff at health club assessed number of exercise sessions participated in each week. No standardised measure of adherence was used. |
| Other outcome measures | i. Aerobic fitness – time spent on a stationary ergometer and treadmill.<br>ii. Strength – tested using Nautilus variable resistance equipment.<br>iii. Pain – VAS (0 – 100) |
| Data analysis | ANOVA was used to compare post-test (6 month) scores between groups. Regression was used to examine factors associated with reduction in pain. Descriptive statistics were provided for adherence data. |
| Treatment outcomes (adherence) | Supervision was found to influence better adherence. Patients in the intervention group who participated in supervised exercise 4 times a week over 6 months did significantly more home exercise compared to the control group who did independent home exercise. The supervised group completed 90.75 (SD 3.3) out of 96 home exercise sessions. The independent group completed 31.95 (SD 17.2) out of 96 sessions ($P < 0.01$). Adherence was 1 of 3 factors found to be associated with a reduction in pain as part of a regression analyses at 6 month follow-up. |
| Treatment outcomes (other) | At 6 months, participants in the experimental group had a significantly lower resting heart rate ($P<0.01$), significantly higher strength ($P<0.01$), significantly less pain ($P<0.01$), and significantly less relapse ($P<0.01$), when compared to the control group. In the regression analysis, 3 factors were found to be associated with a reduction in pain: 1) no. of sessions completed; 2) % body fat reduction; 3) treadmill endurance. This model accounted for 82% of the variance in pain reduction. |

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| | Relationship between level of adherence and outcome (if explored) | Adherence was 1 of 3 factors found to be associated with a reduction in pain as part of a regression analyses at 6 month follow-up. |
| | Baseline predictors of adherence (if explored) | Not explored. |
| | Key adherence conclusions of study authors | The authors concluded that supervision influenced adherence to exercise. |
| | Correspondence | None. |

**Study: Vong et al. (2011) Motivational enhancement therapy in addition to physical therapy improves motivational factors and treatment outcomes in people with low back pain: a randomized controlled trial.**

| | | |
|---|---|---|
| **Population** | N = 88; final N = 76 | Hong Kong. Male and female; aged 18 – 65; experimental group mean age 44.6 years (+-11.2); control group mean age 45.1 (+-10.7); participants had CLBP (> 3 months). Mean duration of pain for experimental group = 41.6 months ± SD 56.8 (3.5 years ± SD 4.7) and for control group = 51.0 months ± SD 71.5 (4.25 years ± SD 6). |
| **Intervention** | | |
| | Experimental group | N = 38; Motivational enhancement therapy and physical therapy (MET + PT).<br><br>Individualised PT sessions across 8 weeks. Sessions included 15 minutes of interferential therapy and specific stretching and strengthening exercises. Sessions incorporated motivational interviewing (MI) techniques and other psychosocial components, which were not specified in the paper |

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| Control | N = 38; individualised PT sessions across 8 weeks. Sessions included 15 minutes of interferential therapy and specific stretching and strengthening exercises. |
| Treatment delivery | 6 physical therapists. |
| Procedure | MET included motivational interviewing strategies and motivation-enhancing factors. The PT programme consisted of interferential therapy and back exercises. Physical therapists integrated MI skills and several psychosocial components designed to enhance the motivation of subjects to engage in treatment and make appropriate behavioural changes. Adherence was based on how many sessions of home exercise patients performed in a day multiplied by how many days they practiced in a week. Adherence was measured in sessions 5, 10, and at 4 week follow-up after end of treatment. |
| Is adherence a primary outcome? | No. It is mentioned in abstract, but is stated in the paper as a secondary outcome. |
| Adherence to home exercise measures | The frequency of practicing the prescribed home exercises was recorded in an exercise log book in both groups. No standardised measure of adherence was used. |
| Other outcome measures | i. Motivational status - Pain Rehabilitation Expectations Scale (Cheing et al., 2010), and Pain Self-Efficacy Questionnaire (Nicholas, 2007).<br>ii. Disability – Roland-Morris Disability Questionnaire (Roland and Morris, 1983).<br>iii. Perceived physical status - 36-Item Short-Form Health Survey physical sub-scale (in Resnik and Dobrykowski, 2005).<br>iv. Pain – VAS (10 cm).<br>v. Physical function – range of movement. |

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| Data analysis | A series of 2-way repeated measures ANCOVA (analysis of covariance) were carried out to compare mean differences between the MET-plus-PT and PT groups. A significance level of 5% was used. |
| Treatment outcomes (adherence) | Participation in a behaviour change programme, including motivational interviewing, was found to influence better adherence. Patients having PT plus motivational interviewing performed significantly more home exercise than those having PT alone at 1 month follow-up (F = 12.11, *P*<.002).<br><br>The MET-plus-PT group performed home exercises 2 times more frequently than the PT group in session 10 (MET-plus-PT, 13.9+-8.2 vs PT, 6.2_3.6sessions/wk) and 1 month follow-up (MET-plus-PT, 12.9+-7.2 vs PT, 5.8+-4.1sessions/wk). No significant interaction (F=0.614, *P*=0.501) or within-group effect (*P*=0.436) was found. |
| Treatment outcomes (other) | The MET-plus-PT group produced significantly greater improvements than the PT group in the following:<br><br>i. Proxy efficacy (*P*=0.001).<br>ii. Working alliance (*P*=0.001).<br>iii. Treatment expectancy (*P*=0.011).<br>iv. Lifting capacity (*P*=0.015).<br>v. 36-Item Short Form Health Survey General Health subscale (*P*=0.015)<br><br>A trend of a greater decrease in VAS and Roland-Morris Disability Questionnaire scores also was found in the MET-plus-PT group than the PT group. However, differences in pain and disability between-groups were not significant. |
| Relationship between level of adherence and outcome (if explored) | Not explored. |
| Baseline predictors of adherence (if explored) | Not explored. |

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| Key adherence conclusions of study authors | The addition of MET to PT treatment can effectively enhance exercise adherence in patients with CLBP compared with PT alone. |
| Correspondence | None. |

*Adherence was considered as a primary outcome if mentioned in the title or abstract, or referred to in a paper as a primary outcome. CLBP - chronic low back pain; LBP – lower back pain; CT - computed tomography; NMR - nuclear magnetic resonance; VAS - visual analogue scale; NSD - no significant difference; ANOVA – analysis of variance; PA - physical activity; MSK - musculoskeletal; PT - physiotherapy; MET - motivational enhancement treatment; MI – motivational interviewing; HLC – health locus of control; SMART goals – specific, measurable, attainable, realistic, and timely goal.

## Appendix 3. 16-item Quality Assessment Tool used in Study 1

Numerous scales have been developed or modified to evaluate the methodological quality of RCTs in physical therapy research. However, most of them have not been tested for validity and reliability (Olivio et al., 2008). For the purposes of the systematic review conducted for Study 1, van Tulder's (2003) 11-item quality assessment tool (QAT) was modified based on the expert opinions of physical therapists and researchers together with items from previously validated QATs. The validated QATs were 'the Maastricht List', de Vet HCW et al., 1997; 'the van Tulder Scale', van Tulder et al., 2003; 'the Bizzini Scale', Bizzini et al., 2003; 'the Cochrane List for Methodological Quality Assessment', Furlan et al., 2009; and 'the Scottish Intercollegiate Guidelines Network checklist', 2012. In addition to the original 11 van Tulder items, six further items were established to ensure adequate quality assessment. These items were selected from QATs described in Olivio et al.'s (2008) systematic review assessing QATs used to assess RCTs in healthcare research. Table 2 (Chapter 3) illustrates the QAT(s) from which each item originated.

The six additional items were:

Item 7: Are reports of the study free of suggestion of selective outcome reporting?
Item 11: Were all relevant outcomes measured in a standard, valid and reliable way?
Item 12: Was the treatment protocol adequately described for the treatment and control groups?
Item 13: Was appropriate statistical analysis used?
Item 14: Was a sample size calculation performed prior to initiation of the study?
Item 15: Was the sample size adequate?

Many QATs contained the same items posed in different ways. These items were discussed with the experts mentioned above, and the most comprehensively worded items were selected for inclusion in the modified QAT. For this reason, the wording of certain items may vary from their wording in the original tool they were sourced from. Guidelines explaining how each item should be scored were based on explanations from the original checklists. The QAT was piloted with four articles by two reviewers. This was followed by assessment of methodological quality of all included studies by the primary researcher.

## Appendix 4a. Prescribed Exercise Questionnaire

**Healthcare providers normally recommend that people with chronic health conditions do exercises and/or activities to improve their quality of life and manage their condition. People often find their own way of doing their exercises/activities. We would like you to tell us how you do yours.**

Please tick all of the boxes that apply to you.

1) What exercise/activity have you been asked to do?

☐ Personal exercise sessions with a healthcare professional

☐ Group exercise sessions

☐ Individualised exercises to do at home, as recommended by a health care professional

☐ Doing regular exercise in general

☐ Walking

☐ Staying active in your daily life

Other _____

2) How often have you been asked to do these exercises and/or activities?

☐ Every day

☐ 4 to 6 days a week

☐ 2 to 3 days a week

☐ 1 day a week

☐ Less than this

Other _____

3) For how long have you been asked to continue doing these exercises and/or activities?

☐ Ongoing

☐ For a fixed duration (please specify) _____

Other (please state) _____

4) How often are you doing these exercises and /or activities?

☐ Every day

☐ 4 to 6 days a week

☐ 2 to 3 days a week

☐ 1 day a week

☐ Not at all

5) If you have stopped doing your exercises/activities, when did you stop and why?

_____

_____

6) In your own words, please can you explain why you have, or have not, done your exercises?

## Appendix 4b. Exercise Adherence Rating Scale (EARS)

For each of the following 6 statements, please tick the box which best describes how you do your recommended exercises/activities. When thinking about your answer, please consider any exercises/activities that you have been asked to do as part of your treatment.

**1. I do my exercises as often as recommended**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

2. **I forget to do my exercises**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**3. I do less exercise than recommended by my healthcare professional**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**4. I fit my exercises into my regular routine**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**5. I don’t get around to doing my exercises**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**6. I do some, but not all, of my exercises**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Scoring the Exercise Adherence Rating Scale (EARS)**

This scoring information relates to the 6-item EARS. The EARS is scored on a 5-point Likert scale (0 - completely agree to 4 - completely disagree). Items 1 and 4 are reverse scored, resulting in a possible score of between 0 and 24. A higher score indicates better adherence.

**Adapting the Exercise Adherence Rating Scale (EARS)**

The Prescribed Exercise Questionnaire may be adapted to suit individual needs. The validated 6-item EARS questionnaire may not be adapted, as this would render the questionnaire as invalid. The 10-item questionnaire (What helps or hinders doing your exercises?) consists of 10-items that relate to reasons why an individual may or may not adhere to prescribed home exercise. Items 4, 5, 6 and 7 require reverse scoring so that a higher score indicates better adherence. These 10-items may be used as single-items that can be added to or adapted to suit individual needs.

## Appendix 4c. What helps or hinders doing your exercises?

For each of the following 10 statements, please tick the box which best describes why you do or don't do your recommended exercises/activities.

**1. I don't have time to do my exercises**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**2. Other commitments prevent me from doing my exercises**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**3. I don't do my exercises when I am tired**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**4. I feel confident about doing my exercises**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**5. My family and friends encourage me to do my exercises**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**6. I do my exercises to improve my health**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**7. I do my exercises because I enjoy them**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**8. I adjust the way I do my exercises to suit myself**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**9. I stop exercising when my pain is worse**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**10. I'm not sure how to do my exercises**

| *Completely agree* | | | | *Completely disagree* |
|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* |
| ☐ | ☐ | ☐ | ☐ | ☐ |

## Appendix 5. Invitation Letter

**Department of Psychology (at Guy's)**

**Health Psychology Section**

5th Floor, Bermondsey Wing

Guy's Hospital

London SE1 9RT

Tel: 020 7188 0180 Fax: 020 7188 0184

*REC study number: 10/H0808/9*

Dear

*RE STUDY*: Executive function, beliefs and adherence to back pain exercises

We are contacting you because we are carrying out a research study in people currently undergoing treatment for back pain with their local physiotherapist at Guy's, St Thomas' or King's College Hospitals. We would like to tell you about the study we are conducting and see if you would be interested in taking part; there is absolutely no obligation to do so and whatever you decide will not affect your treatment in any way.

The study is looking at what people think about their back exercises and what may influence these perceptions. We are using paper-and-pencil tests to ask not only about what you think of your exercises but also to find out about how you process and remember information. We are aiming to find out whether people's ideas about back exercises or how they process and remember information have any impact on their treatment. We hope that if we understand this better, it will eventually help us to develop ways of promoting exercise for back pain.

We enclose an information sheet for the study. It explains exactly what would happen if you agreed to take part.

If, after a brief screening (which would be carried out over the phone if you are interested in taking part), you were suitable for the study, then we would spend between 45 and 60 minutes asking you additional questions and doing our paper-and-pencil, and spoken, testing at the physiotherapy department. This would be carried out immediately before your clinic appointment and would not require a separate trip.

We will phone you in a few days to see if you are interested in taking part in the study. Please do not feel any obligation to take part and discuss whether you wish to take part with family or friends if you want to. Please contact us if you would like more information.

With best wishes,

**Dr Emma Godfrey**

Lecturer in Psychology

## Appendix 6. Screening Questions

Have you had low back pain for 3 months or more?

Are you pregnant?

**Physical and mental health**

Are you, or have you ever been diagnosed with:

| | | | |
|---|---|---|---|
| | dementia? | Y | N |
| | major depression? | Y | N |
| | other psychiatric illness? | Y | N |

---

| | | | |
|---|---|---|---|
| Do you have a history of: | head injury? | Y | N |
| | stroke? | Y | N |
| | other CNS disorder? | Y | N |

---

Do you currently have any <u>major</u> health problems other than your back? Y N

Please could you tell me what they are?

1. _____
2. _____
3. _____

**Fluency**

The tests and questionnaires in this study involve reading and listening to English.

Would you say that you are fluent in written and spoken english? Y N

**Vision**

One of the tests will include colour. Could you tell me if you are colour blind? Y N

REC: 10/H0808/9
E Godfrey
Form Created: 02 October 2009
Form Edited: 19th January 2011

## Appendix 7. Sports Injury Rehabilitation Adherence Scale (SIRAS)

## (Kolt et al., 2007)

1. **Indicate the number that best describes the intensity with which this patient completed their rehabilitation exercises:**

Minimum effort 1 2 3 4 5 Maximum

2. **How frequently did this patient follow your instructions and advice?**

Never 1 2 3 4 5 Always

3. **How receptive was this patient to changes in the rehablilitation programme?**

Very unreceptive 1 2 3 4 5 Very receptive

If you would like to comment on any of the above please use this space or over the page:

Thank you for your co-operation

_____

_____

_____

_____

_____

All information will remain confidential.

## Appendix 8. Demographics Questionnaire

1. **Are you male or female?**
   - ☐ Male
   - ☐ Female

2. **What is your date of birth?**
   - Day ☐
   - Month ☐
   - Year ☐

3. **What is your age today?**
   - Age ☐

4. **What is your height?**
   - Feet and inches **OR** ☐
   - centimetres ☐

5. **What is your weight?**
   - Stone **OR** ☐
   - Kilograms ☐

6. **To which of these ethnic groups do you consider you belong?**
   - ☐ **White** - any white background
   - ☐ **Mixed** - White and Black Caribbean
   - ☐ **Mixed** - White and Black African
   - ☐ **Mixed** - White and Asian
   - ☐ **Asian or Asian British** - Indian
   - ☐ **Asian or Asian British** - Pakistani
   - ☐ **Asian or Asian British** - Bangladeshi
   - ☐ **Black or Black British** - Caribbean
   - ☐ **Black or Black British** - African
   - ☐ **Asian or Asian British**
   - ☐ **Chinese**
   - ☐ **Other**

7. **What is the highest level of education you have completed?**
   - ☐ No formal education
   - ☐ GCSE/O Levels
   - ☐ A Levels/HNC
   - ☐ University Level
   - ☐ Graduate/Professional

   **Please Specify:** ☐

8. **Please tick which applies to your employment status:**
   - ☐ Employed full-time
   - ☐ Employed part-time
   - ☐ Unemployed
   - ☐ Self employed
   - ☐ Retired (because of age)
   - ☐ Retired (because of back pain)
   - ☐ Retired (because of other ill health)
   - ☐ Student
   - ☐ Housewife/husband
   - ☐ Other

9. **If you are unemployed or retired, do you intend to return to work?**
   - ☐ YES
   - ☐ NO

   **How long have you been unemployed / retired?** ☐

10. **If you are currently employed:**
    - Occupation ☐
    - Job Title ☐

**11. Have you had to stop or reduce work because of your back pain?**

- ☐ YES
- ☐ NO

**12. If YES:**

How many days in the last 6 months ☐

**OR** how many hours per week less ☐

**13. Which of these state benefits (if any) have you received in the last 6 months?**

- ☐ Incapacity Benefit
- ☐ Disability living allowance mobility component
- ☐ Disabled Person's Tax Credit
- ☐ State retirement pension
- ☐ Statutory Sick pay
- ☐ Other
- ☐ None

**14. <u>MEDICATION</u> - Are you taking any prescription medication for your back pain?**

- ☐ YES
- ☐ NO

**15. Have you taken any medication today?**

- ☐ YES
- ☐ NO

**16. If so, what have you taken and how long ago did you take it?**

**17. Is English your first language?**

## Appendix 9. General Health and Back Pain Questions

**4. Would you say your general health is:**

- ☐ Excellent
- ☐ Very Good
- ☐ Good
- ☐ Fair
- ☐ Poor

**5. How long have you suffered from low back pain?**

- ☐ Under 6 months
- ☐ 6 months to 1 year
- ☐ 1 to 3 years
- ☐ 3 to 5 years
- ☐ Over 5 years

Please specify: _____

**6. Is there someone available to give you good advice about a problem?**

- ☐ Yes
- ☐ No

## Appendix 10. Hospital Anxiety and Depression Questionnaire

**Please read each item and tick the reply that comes closest to how you've been feeling in the past week.**

**Don't take too long over your replies; your immediate reaction to each item will probably be more accurate than a long thought-out response.**

1. **I feel tense or 'wound up'**
   - ☐ Most of the time
   - ☐ A lot of the time
   - ☐ From time to time, occasionally
   - ☐ Not at all

2. **I still enjoy the things I used to enjoy**
   - ☐ Definitely as much
   - ☐ Not quite so much
   - ☐ Only a little
   - ☐ Hardly at all

3. **I get a sort of frightened feeling as if something awful is going to happen**
   - ☐ Very definitely and quite badly
   - ☐ Yes, but not too badly
   - ☐ A little, but it doesn't worry me
   - ☐ Not at all

4. **I can laugh and see the funny side of things**
   - ☐ As much as I always could
   - ☐ Not quite so much now
   - ☐ Definitely not so much now
   - ☐ Not at all

5. **Worrying thoughts go through my mind**
   - ☐ A great deal of the time
   - ☐ A lot of the time
   - ☐ From time to time but not too often
   - ☐ Only occasionally

6. **I feel cheerful**
   - ☐ Not at all
   - ☐ Not often
   - ☐ Sometimes
   - ☐ Most of the time

7. **I can sit and feel relaxed**
   - ☐ Definitely
   - ☐ Usually
   - ☐ Not often
   - ☐ Not at all

8. **I feel as if I'm slowed down**
   - ☐ Nearly all the time
   - ☐ Very often
   - ☐ Sometimes
   - ☐ Not at all

9. **I get a sort of frightened feeling like 'butterflies' in the stomach**

- ☐ Not at all
- ☐ Occasionally
- ☐ Quite often
- ☐ Very often

10. **I have lost interest in my appearance**

- ☐ Definitely
- ☐ I don't take as much care as I should
- ☐ I may not take quite as much care
- ☐ I take just as much care as ever

11. **I feel restless, as if I have to be on the move**

- ☐ Very much indeed
- ☐ Quite a lot
- ☐ Not very much
- ☐ Not at all

12. **I look forward with enjoyment to things**

- ☐ As much as I ever did
- ☐ Rather less than I used to
- ☐ Hardly at all
- ☐ Not at all

13. **I get sudden feelings of panic**

- ☐ Very often indeed
- ☐ Quite often
- ☐ Not very often
- ☐ Not at all

14. **I can enjoy a good book, or radio, or TV programme**

- ☐ Often
- ☐ Sometimes
- ☐ Not often
- ☐ Very seldom

## Appendix 11. Brief Illness Perception Questionnaire

**For the following questions, please tick the number that best corresponds to your views:**

1. **How much does your back pain affect your life?**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** is 'no affect at all' & **10** is 'severely affects my life' | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

2. **How long do you think your back pain will continue?**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** is 'a very short time' & **10** is 'forever' | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

3. **How much control do you feel you have over your back pain?**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** is 'absolutely no control' & **10** is 'extreme amount of control' | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

4. **How much do you think your treatment can help your back pain?**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** is 'not at all' & **10** is 'extremely helpful' | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

5. **How much do you experience symptoms from your back pain?**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** is 'no symptoms at all' & **10** is 'many severe symptoms' | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

6. **How concerned are you about your back pain?**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** is 'not at all concerned' & **10** is 'extremely concerned' | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

7. **How well do you feel you understand your back pain?**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** is 'don't understand at all' & **10** is 'understand very clearly' | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

8. **How much does your back pain affect you emotionally? (e.g. does it make you angry, scared, upset or depressed?**

**0** is 'not at all affected emotionally' & **10** is 'extremely affected emotionally'

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

9. **Please list in rank-order the three most important factors that you believe caused <u>your back pain</u>. The most important causes for me:**

1) 

2) 

3) 

## Appendix 12. Fear-Avoidance Beliefs Questionnaire

**Here are some of the things which other patients have told us about their pain.**

**For each statement please tick a number from 0 to 6 to say how much physical activities such as bending, lifting, walking or driving *affect or would affect* your back pain.**

1. **My pain is caused by physical activity**

| *Completely Agree* | | | *Unsure* | | | *Completely Disagree* |
|---|---|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* | *5* | *6* |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

2. **Physical activity makes my pain worse**

| *Completely Agree* | | | *Unsure* | | | *Completely Disagree* |
|---|---|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* | *5* | *6* |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

3. **Physical activity might harm my back**

| *Completely Agree* | | | *Unsure* | | | *Completely Disagree* |
|---|---|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* | *5* | *6* |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

4. **I should not do physical activities which (might) make my pain worse**

| *Completely Agree* | | | *Unsure* | | | *Completely Disagree* |
|---|---|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* | *5* | *6* |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

5. **I cannot do physical activities which (might) make my pain worse**

| *Completely Agree* | | | *Unsure* | | | *Completely Disagree* |
|---|---|---|---|---|---|---|
| *0* | *1* | *2* | *3* | *4* | *5* | *6* |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**The following statements are about how your normal work *affects* or *would affect* your back pain:**

6. **My pain was caused by my work or by an accident at work**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

7. **My work aggravated my pain**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

8. **My work is too heavy for me**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

9. **My work makes or would make my pain worse**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

10. **My work might harm my back**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

11. **I should not do my normal work with my present pain**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

12. **I cannot not do my normal work with my present pain**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

13. **I cannot do my normal work till my pain is treated**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

14. **I do not think that I will be back to my normal work within 3 months**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

15. **I do not think that I will ever be able to go back to that work**

| Completely Agree | | | Unsure | | | Completely Disagree |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

## Appendix 13. Pain Catastrophizing Questionnaire

**Everyone experiences painful situations at some point in their lives. We are interested in the types of thoughts and feelings that you have when you are in pain. Listed below are 13 statements describing different thoughts and feelings that may be associated with back pain. Please tick the box that indicates the degree to which you have these thoughts and feelings when you are experiencing back pain.**

| | | | | | |
|---|---|---|---|---|---|
| **1.** | **I worry all the time about whether the pain will end** | | | | |
| *Not at all* ☐ | *To a slight degree* ☐ | *To a moderate degree* ☐ | *To a great degree* ☐ | *All the time* ☐ | |
| **2.** | **I feel I can't go on** | | | | |
| *Not at all* ☐ | *To a slight degree* ☐ | *To a moderate degree* ☐ | *To a great degree* ☐ | *All the time* ☐ | |
| **3.** | **It's terrible and I think it's never going to get any better** | | | | |
| *Not at all* ☐ | *To a slight degree* ☐ | *To a moderate degree* ☐ | *To a great degree* ☐ | *All the time* ☐ | |
| **4.** | **It's awful and I feel that it overwhelms me** | | | | |
| *Not at all* ☐ | *To a slight degree* ☐ | *To a moderate degree* ☐ | *To a great degree* ☐ | *All the time* ☐ | |
| **5.** | **I feel I can't stand it anymore** | | | | |
| *Not at all* ☐ | *To a slight degree* ☐ | *To a moderate degree* ☐ | *To a great degree* ☐ | *All the time* ☐ | |

6. **I become afraid that the pain will get worse**

| Not at all | To a slight degree | To a moderate degree | To a great degree | All the time |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

7. **I keep thinking of other painful events**

| Not at all | To a slight degree | To a moderate degree | To a great degree | All the time |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

8. **I anxiously want the pain to go away**

| Not at all | To a slight degree | To a moderate degree | To a great degree | All the time |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

9. **I can't seem to keep it out of my mind**

| Not at all | To a slight degree | To a moderate degree | To a great degree | All the time |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

10. **I keep thinking about how much it hurts**

| Not at all | To a slight degree | To a moderate degree | To a great degree | All the time |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

11. **I keep thinking about how badly I want the pain to stop**

| Not at all | To a slight degree | To a moderate degree | To a great degree | All the time |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

12. **There's nothing I can do to reduce the intensity of the pain**

| Not at all | To a slight degree | To a moderate degree | To a great degree | All the time |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

13. **I wonder whether something serious may happen**

| Not at all | To a slight degree | To a moderate degree | To a great degree | All the time |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

## Appendix 14. Short-form McGill Pain Questionnaire

**Please tick any word that applies to your back pain experience under the heading of NONE, MILD, MODERATE or SEVERE.**

**1.**

| | *None* | *Mild* | *Moderate* | *Severe* |
|---|---|---|---|---|
| **Throbbing** | ☐ | ☐ | ☐ | ☐ |
| **Shooting** | ☐ | ☐ | ☐ | ☐ |
| **Stabbing** | ☐ | ☐ | ☐ | ☐ |
| **Sharp** | ☐ | ☐ | ☐ | ☐ |
| **Cramping** | ☐ | ☐ | ☐ | ☐ |
| **Gnawing** | ☐ | ☐ | ☐ | ☐ |
| **Hot - Burning** | ☐ | ☐ | ☐ | ☐ |
| **Aching** | ☐ | ☐ | ☐ | ☐ |
| **Heavy** | ☐ | ☐ | ☐ | ☐ |
| **Tender** | ☐ | ☐ | ☐ | ☐ |
| **Splitting** | ☐ | ☐ | ☐ | ☐ |
| **Tiring - Exhausting** | ☐ | ☐ | ☐ | ☐ |
| **Sickening** | ☐ | ☐ | ☐ | ☐ |
| **Fearful** | ☐ | ☐ | ☐ | ☐ |
| **Punishing - Cruel** | ☐ | ☐ | ☐ | ☐ |

**2.** **Please rate your <u>present</u> back pain:**

| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* |
|---|---|---|---|---|---|---|---|---|---|---|
| '1' is NO PAIN and '10' is WORST POSSIBLE PAIN: | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**3.** **How strong is your overall back pain experience? (Please tick one)**

- ☐ No Pain
- ☐ Mild
- ☐ Discomfort
- ☐ Distressing
- ☐ Horrible
- ☐ Excrutiating

## Appendix 15. Roland Morris Disability Questionnaire

**When your back hurts, you may find it difficult to do some of the things you normally do.**

**Please tick <u>all</u> of the statements that describe you lately.**

1. ☐ I stay at home most of the time because of my back
2. ☐ I change position frequently to try and get my back comfortable
3. ☐ I walk more slowly than usual because of my back
4. ☐ Because of my back I am not doing any of the jobs that I usually do around the house
5. ☐ Because of my back, I use a handrail to get upstairs
6. ☐ Because of my back, I lie down to rest more often
7. ☐ Because of my back, I have to hold on to something to get out of an easy chair
8. ☐ Because of my back, I try to get other people to do things for me
9. ☐ I get dressed more slowly then usual because of my back
10. ☐ I only stand for short periods of time because of my back
11. ☐ Because of my back, I try not to bend or kneel down

12. ☐ I find it difficult to get out of a chair because of my back

13. ☐ My back is painful almost all the time

14. ☐ I find it difficult to turn over in bed because of my back

15. ☐ My appetite is not very good because of my back pain

16. ☐ I have trouble putting on my socks (or stockings) because of the pain in my back

17. ☐ I only walk short distances because of my back

18. ☐ I sleep less well because of my back

19. ☐ Because of my back pain, I get dressed with help from someone else

20. ☐ I sit down for most of the day because of my back

21. ☐ I avoid heavy jobs around the house because of my back

22. ☐ Because of my back pain, I am more irritable and bad tempered with people than usual

23. ☐ Because of my back, I go upstairs more slowly than usual

24. ☐ I stay in bed most of the time because of my back

# Appendix 16. Correlations between independent variables and dependent variable (EARS) in Study 3

| | | | EARS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Gender | Pearson | -.268* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .021 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Age | Pearson | -.121 | -.079 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .305 | .433 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Level of education | Pearson | -.074 | .131 | -.338** | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .533 | .194 | .001 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Time in pain | Pearson | -.326** | .033 | .270** | -.117 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .005 | .744 | .007 | .248 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Social support | Pearson | -.131 | -.006 | -.045 | .030 | .072 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .283 | .957 | .666 | .775 | .488 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | General health | Pearson | -.316** | .132 | .161 | -.192 | .210* | .129 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .006 | .190 | .109 | .055 | .036 | .216 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | HADS Anxiety Total | Pearson | -.216* | .377** | -.147 | .054 | .002 | .058 | .239* | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .068 | .000 | .149 | .597 | .988 | .579 | .018 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | HADS Depression Total | Pearson | -.234* | .283** | -.056 | -.077 | .152 | .185 | .464** | .669** | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .048 | .005 | .585 | .450 | .135 | .076 | .000 | .000 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | HADS Distress total | Pearson | -.243* | .364** | -.114 | -.008 | .079 | .128 | .377** | .924** | .902** | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .040 | .000 | .264 | .935 | .439 | .221 | .000 | .000 | .000 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | IPQ Perceived Conseau. | Pearson | -.176 | .183 | .211* | -.098 | .087 | .071 | .161 | .284** | .397** | .368** | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .142 | .073 | .038 | .338 | .399 | .501 | .114 | .005 | .000 | .000 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | IPQ Time Line | Pearson | -.257* | .300** | .132 | -.080 | .420** | .076 | .389** | .327** | .455** | .423** | .387** | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .031 | .003 | .196 | .435 | .000 | .472 | .000 | .001 | .000 | .000 | .000 | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | IPQ Perceived control | Pearson | -.129 | .069 | .066 | -.027 | .030 | .042 | .145 | .108 | .224* | .177 | .174 | .342** | 1 | | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .283 | .503 | .521 | .795 | .772 | .692 | .157 | .293 | .027 | .082 | .089 | .001 | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | IPQ Treatment control | Pearson | -.165 | .184 | -.056 | -.025 | -.037 | .196 | .329** | .279** | .361** | .347** | .055 | .277** | .358** | 1 | | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .170 | .071 | .583 | .810 | .719 | .062 | .001 | .006 | .000 | .000 | .590 | .006 | .000 | | | | | | | | | | | | | | | | | | | | | | |
| 14 | IPQ Identity | Pearson | -.129 | .221* | .194 | -.169 | .191 | -.002 | .242* | .238* | .341** | .313** | .614** | .381** | .044 | .054 | 1 | | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .285 | .029 | .057 | .098 | .061 | .987 | .017 | .019 | .001 | .002 | .000 | .000 | .670 | .602 | | | | | | | | | | | | | | | | | | | | | |
| 15 | IPQ Concern | Pearson | .072 | .113 | .167 | -.091 | .156 | .047 | .071 | .139 | .204* | .186 | .625** | .422** | .200* | -.019 | .504** | 1 | | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .550 | .269 | .102 | .375 | .127 | .655 | .488 | .174 | .045 | .069 | .000 | .000 | .050 | .850 | .000 | | | | | | | | | | | | | | | | | | | | |
| 16 | IPQ Understanding | Pearson | -.063 | .177 | .038 | -.126 | -.138 | .137 | .063 | .247* | .246* | .270** | .136 | .024 | .368** | .364** | .105 | .112 | 1 | | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .599 | .082 | .715 | .218 | .177 | .192 | .538 | .015 | .015 | .008 | .186 | .818 | .000 | .000 | .308 | .274 | | | | | | | | | | | | | | | | | | | |
| 17 | IPQ Emotional response | Pearson | -.251* | .349** | .210* | -.061 | .099 | .123 | .271** | .489** | .533** | .557** | .498** | .388** | .174 | .243* | .513** | .481** | .160 | 1 | | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .035 | .000 | .039 | .556 | .335 | .242 | .007 | .000 | .000 | .000 | .000 | .000 | .088 | .016 | .000 | .000 | .117 | | | | | | | | | | | | | | | | | | |
| 18 | Brief IPQ total | Pearson | -.235* | .330** | .192 | -.138 | .158 | .145 | .343** | .436** | .568** | .545** | .688** | .656** | .572** | .494** | .630** | .651** | .500** | .697** | 1 | | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .048 | .001 | .059 | .178 | .122 | .169 | .001 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | | | | | | | | | | | | | | | | | |
| 19 | RMDQ Baseline | Pearson | -.252* | .173 | .318** | -.132 | .188 | .148 | .281** | .427** | .567** | .540** | .526** | .434** | .239* | .225* | .456** | .450** | .184 | .580** | .624** | 1 | | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .031 | .088 | .001 | .191 | .062 | .156 | .005 | .000 | .000 | .000 | .000 | .000 | .018 | .027 | .000 | .000 | .071 | .000 | .000 | | | | | | | | | | | | | | | | |
| 20 | FABQ - Exercise | Pearson | -.107 | .167 | .149 | -.175 | -.047 | -.005 | .116 | .186 | .236* | .230* | .259* | .161 | .031 | .219* | .123 | .203* | .275** | .243* | .309** | .270** | 1 | | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .374 | .105 | .146 | .089 | .648 | .960 | .261 | .070 | .020 | .024 | .011 | .120 | .767 | .033 | .236 | .048 | .007 | .018 | .002 | .008 | | | | | | | | | | | | | | | |
| 21 | FABQ - Work | Pearson | -.009 | .165 | .127 | -.260* | -.106 | .017 | .285** | .430** | .387** | .450** | .386** | .201 | .054 | .163 | .362** | .299** | .273** | .394** | .428** | .424** | .189 | 1 | | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .939 | .109 | .221 | .011 | .309 | .870 | .005 | .000 | .000 | .000 | .000 | .052 | .608 | .117 | .000 | .003 | .008 | .000 | .000 | .000 | .066 | | | | | | | | | | | | | | |
| 22 | Present pain intensity baseline | Pearson | -.344** | .135 | .235* | -.267** | .200 | .010 | .185 | .261* | .366** | .338** | .560** | .243* | .280** | .092 | .453** | .441** | .079 | .430** | .518** | .581** | .137 | .232* | 1 | | | | | | | | | | | | |
| | | Sig. (2-tailed) | .003 | .194 | .023 | .009 | .054 | .929 | .074 | .011 | .000 | .001 | .000 | .019 | .007 | .380 | .000 | .000 | .449 | .000 | .000 | .000 | .191 | .027 | | | | | | | | | | | | | |
| 23 | Overall pain intensity baseline | Pearson | -.255* | .072 | .217* | -.099 | .000 | .060 | .139 | .187 | .327** | .275** | .413** | .073 | .225* | .177 | .377** | .232* | .245* | .389** | .438** | .496** | .072 | .174 | .565** | 1 | | | | | | | | | | | |
| | | Sig. (2-tailed) | .031 | .493 | .035 | .342 | .997 | .575 | .182 | .071 | .001 | .007 | .000 | .486 | .030 | .090 | .000 | .025 | .018 | .000 | .000 | .000 | .494 | .099 | .000 | | | | | | | | | | | | |
| 24 | PCS - Helplessness | Pearson | -.278* | .309** | -.009 | -.103 | .004 | .145 | .237* | .542** | .603** | .624** | .411** | .402** | .227* | .335** | .398** | .316** | .216* | .638** | .600** | .643** | .266** | .381** | .427** | .466** | 1 | | | | | | | | | | |
| | | Sig. (2-tailed) | .018 | .002 | .929 | .314 | .967 | .165 | .019 | .000 | .000 | .000 | .000 | .000 | .026 | .001 | .000 | .002 | .033 | .000 | .000 | .000 | .009 | .000 | .000 | .000 | | | | | | | | | | | |
| 25 | PCS -Magnification | Pearson | -.186 | .233* | .047 | -.111 | -.075 | .038 | .207* | .556** | .593** | .627** | .358** | .357** | .218* | .381** | .376** | .311** | .214* | .586** | .570** | .507** | .349** | .380** | .357** | .400** | .805** | 1 | | | | | | | | | |
| | | Sig. (2-tailed) | .118 | .021 | .647 | .275 | .465 | .721 | .041 | .000 | .000 | .000 | .000 | .000 | .032 | .000 | .000 | .002 | .035 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | | | | | | | | | | |
| 26 | PCS - Rumination | Pearson | -.201 | .152 | .138 | -.179 | .000 | .085 | .247* | .547** | .500** | .574** | .401** | .366** | .233* | .207* | .389** | .356** | .164 | .631** | .557** | .568** | .337** | .420** | .375** | .309** | .831** | .812** | 1 | | | | | | | | |
| | | Sig. (2-tailed) | .090 | .134 | .177 | .077 | 1.000 | .420 | .014 | .000 | .000 | .000 | .000 | .000 | .022 | .042 | .000 | .000 | .108 | .000 | .000 | .000 | .001 | .000 | .000 | .002 | .000 | .000 | | | | | | | | | |
| 27 | PCS Total | Pearson | -.248* | .254* | .057 | -.139 | -.015 | .108 | .249* | .581** | .601** | .646** | .421** | .404** | .241* | .319** | .414** | .349** | .210* | .663** | .614** | .626** | .328** | .420** | .418** | .423** | .958** | .902** | .941** | 1 | | | | | | | |
| | | Sig. (2-tailed) | .036 | .011 | .580 | .172 | .885 | .302 | .013 | .000 | .000 | .000 | .000 | .000 | .017 | .001 | .000 | .000 | .039 | .000 | .000 | .000 | .001 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | | | | | | | |
| 28 | WTAR Pre-morbid IQ | Pearson | .023 | -.187 | -.294** | .620** | -.035 | -.025 | -.286** | -.114 | -.195 | -.167 | -.027 | -.112 | -.067 | -.049 | -.217* | -.138 | -.098 | -.259* | -.203 | -.299** | -.182 | -.406** | -.189 | -.095 | -.184 | -.131 | -.221* | -.198 | 1 | | | | | | |
| | | Sig. (2-tailed) | .849 | .071 | .004 | .000 | .736 | .816 | .005 | .277 | .062 | .110 | .801 | .287 | .523 | .645 | .037 | .190 | .353 | .013 | .052 | .004 | .084 | .000 | .076 | .378 | .077 | .209 | .033 | .057 | | | | | | | |
| 29 | Stroop 18 to 49 years | Pearson | .066 | -.059 | -.223 | .078 | .007 | .149 | -.145 | .016 | -.062 | -.023 | -.194 | -.027 | -.111 | .104 | -.167 | -.359** | .025 | -.263* | -.199 | -.257* | .161 | -.291* | -.309** | -.180 | -.010 | -.020 | -.018 | -.016 | .373** | 1 | | | | | |
| | | Sig. (2-tailed) | .631 | .613 | .053 | .503 | .950 | .204 | .211 | .892 | .600 | .846 | .098 | .819 | .348 | .378 | .155 | .002 | .830 | .023 | .090 | .026 | .175 | .012 | .009 | .134 | .930 | .864 | .880 | .893 | .001 | | | | | | |
| 30 | Stroop over 50 years | Pearson | .027 | .319 | -.208 | .272 | .504* | .132 | .190 | .271 | .060 | .220 | -.175 | .092 | -.306 | .089 | .519* | -.399* | .314 | .232 | -.061 | -.568* | -.187 | -.126 | -.345 | .082 | -.233 | -.153 | -.217 | -.221 | .000 | | 1 | | | | |
| | | Sig. (2-tailed) | .924 | .197 | .408 | .274 | .033 | .626 | .451 | .292 | .818 | .397 | .501 | .724 | .233 | .735 | .033 | .113 | .220 | .370 | .815 | .014 | .473 | .642 | .175 | .756 | .368 | .557 | .403 | .394 | 1.000 | | | | | | |
| 31 | Stroop test 18-65 years | Pearson | -.034 | .125 | -.585** | .316** | .033 | .182 | -.086 | .165 | .112 | .153 | -.203 | -.032 | -.135 | .096 | -.023 | -.295** | -.031 | -.128 | -.152 | -.310** | -.093 | -.154 | -.303** | -.168 | -.027 | -.079 | -.117 | -.073 | .312** | 1.000** | 1.000** | 1 | | | |
| | | Sig. (2-tailed) | .779 | .230 | .000 | .002 | .752 | .086 | .409 | .115 | .286 | .145 | .054 | .760 | .202 | .366 | .831 | .005 | .773 | .226 | .150 | .002 | .383 | .149 | .004 | .117 | .798 | .456 | .266 | .487 | .002 | 0.000 | 0.000 | | | | |
| 32 | ZooMap - formulation | Pearson | .079 | .071 | -.125 | .175 | .010 | -.025 | -.167 | -.168 | -.140 | -.170 | -.182 | -.097 | .126 | -.100 | -.332** | -.188 | -.063 | -.181 | -.199 | -.282** | -.236* | -.290** | -.144 | -.212* | -.189 | -.210* | -.177 | -.201 | .203 | .110 | -.200 | .114 | 1 | | |
| | | Sig. (2-tailed) | .507 | .493 | .224 | .087 | .925 | .810 | .104 | .105 | .178 | .101 | .081 | .356 | .230 | .341 | .001 | .071 | .550 | .082 | .056 | .006 | .023 | .005 | .173 | .043 | .069 | .043 | .088 | .052 | .052 | .349 | .427 | .279 | | | |
| 33 | ZooMap - execution | Pearson | .063 | .011 | -.151 | .321** | .052 | .005 | -.106 | -.193 | -.069 | -.148 | .018 | -.186 | -.114 | -.115 | -.063 | -.105 | -.268** | -.101 | -.204* | -.140 | -.284** | -.210* | .002 | .020 | -.089 | -.153 | -.201 | -.149 | .293** | .225 | .226 | .327** | .237* | 1 | |
| | | Sig. (2-tailed) | .599 | .912 | .141 | .001 | .613 | .965 | .305 | .062 | .511 | .156 | .864 | .074 | .276 | .274 | .547 | .316 | .010 | .337 | .049 | .175 | .006 | .046 | .988 | .850 | .394 | .141 | .052 | .151 | .005 | .054 | .366 | .001 | .020 | | |
| 34 | Zoo Map total | Pearson | .215 | .123 | -.280** | .296** | -.081 | .023 | -.174 | -.132 | -.079 | -.118 | -.130 | -.061 | .088 | -.098 | -.277** | -.194 | -.110 | -.161 | -.187 | -.273* | -.221* | -.241* | -.174 | -.193 | -.143 | -.188 | -.156 | -.166 | .320* | .251* | .221 | .372** | .673** | .453** | 1 | |
| | | Sig. (2-tailed) | .070 | .233 | .006 | .003 | .432 | .831 | .091 | .203 | .448 | .258 | .215 | .564 | .402 | .348 | .007 | .062 | .293 | .124 | .073 | .007 | .034 | .021 | .098 | .066 | .171 | .070 | .134 | .109 | .002 | .031 | .379 | .000 | .000 | .000 | |
| 35 | BW digit span | Pearson | .050 | -.163 | -.208* | .316** | .108 | .130 | -.063 | -.099 | .050 | -.032 | -.018 | .111 | .008 | -.109 | -.085 | -.205* | -.206* | -.254* | -.155 | -.105 | -.200 | -.308** | -.225* | -.034 | -.083 | -.169 | -.148 | -.131 | .506** | .356** | .193 | .365** | .179 | .287** | .311** | 1 |
| | | Sig. (2-tailed) | .680 | .122 | .047 | .002 | .305 | .225 | .552 | .349 | .637 | .766 | .867 | .297 | .939 | .305 | .425 | .052 | .052 | .016 | .145 | .322 | .060 | .003 | .035 | .757 | .432 | .110 | .161 | .215 | .000 | .002 | .458 | .000 | .088 | .006 | .003 | |

## Appendix 17. Hierarchical regression using multiply imputed data for sensitivity analysis (n=69; Study 3)

| | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| **Model** | **B** | **SE B** | **β' (x̌)** | **β (range)** | **Sig.** |
| **Step 1** | | | | | |
| Constant | 15.399 | .930 | - | - | .000 |
| Gender | 4.758 | .912 | .290 | .208 – .371 | .033* |
| Age | -.080 | .962 | -.138 | -.073 – -.190 | .220 |
| Education | -3.002 | .915 | -.185 | -.100 – -.299 | .172 |
| **Step 2** | | | | | |
| Constant | 22.197 | .968 | - | - | .000 |
| Gender | 3.585 | .913 | .218 | .124 – .280 | .095 |
| Age | -.045 | .912 | -.085 | .006 – -.180 | .590 |
| Education | -4.465 | .901 | -.276 | -.196 – -.409 | .046* |
| General health | -2.062 | .923 | -.289 | -.203 – -.377 | .023* |
| Duration of pain | -.331 | .935 | -.287 | -.195 – -.335 | .021* |
| HADS distress | -.035 | .955 | -.035 | -.008 – -.117 | .816 |
| Brief IPQ total | .072 | .972 | .119 | .064 – .196 | .441 |
| PCS total | .078 | .938 | .122 | -.027– .389 | .743 |
| SF-MPQ present pain | -1.008 | .959 | .247 | -.272 – -.420 | .008** |
| RMDQ disability | .242 | .928 | .178 | .039 – .295 | .313 |
| **Step 3** | | | | | |
| Constant | 19.960 | .912 | - | - | .002** |
| Gender | 3.844 | .906 | .233 | .130 – .308 | .086 |
| Age | -.035 | .089 | -.061 | .024 – -.173 | .702 |
| Education | -4.849 | 2.054 | -.300 | -.228 – -.419 | .030* |
| General health | -1.983 | .822 | -.278 | -.199 – -.367 | .021* |
| Duration of pain | -.327 | .135 | -.283 | -.292 – -.318 | .020* |
| HADS distress | -.024 | .154 | -.025 | .000 – -.118 | .876 |
| Brief IPQ total | .079 | .094 | .129 | .062 – .210 | .402 |
| PCS total | .080 | .232 | .165 | -.031 – .369 | .731 |
| SF-MPQ present pain | -1.020 | .369 | .326 | -.282 – -.426 | .007** |
| RMDQ disability | .274 | .225 | .201 | .076 – .304 | .229 |
| Zoo Map test | .728 | .891 | .123 | -.013 – .265 | .433 |

*Note*. ' Arithmetic means calculated for β for multiply imputed data. * p < .05. ** p < .01.

**Appendix 18. Table showing $R^2$ across the 5 multiply imputed regression models (n=69; Study 3)**

| Imputation number | Model | $R^2$ |
|---|---|---|
| 1 | 1 | .146 |
| | 2 | .407 |
| | 3 | .408 |
| 2 | 1 | .111 |
| | 2 | .378 |
| | 3 | .432 |
| 3 | 1 | .183 |
| | 2 | .420 |
| | 3 | .420 |
| 4 | 1 | .188 |
| | 2 | .476 |
| | 3 | .497 |
| 5 | 1 | .078 |
| | 2 | .411 |
| | 3 | .429 |

*Note*. ǂ Arithmetic mean calculated for $R^2$

## Appendix 19. Summary of regression analyses for variables predicting adherence as assessed by the six individual EARS items (n=69; Study 3)

### Regression 3.

### EARS item 1: I do my exercises as often as recommended.

| Variable | B | SE B | β | Sig. |
|---|---|---|---|---|
| Age | -.020 | .017 | -.178 | .243 |
| Gender | .845 | .438 | .263 | .059 |
| Education | -.301 | .512 | -.089 | .559 |
| WTAR | -.002 | .021 | -.015 | .934 |
| Stroop test | -.009 | .017 | -.082 | .592 |
| Zoo Map test | .182 | .175 | .140 | .302 |
| Digit span B/W | -.029 | .114 | -.038 | .798 |
| $R^2$ | | .104 | | |
| F | | .984 | | |

*Note.* * p < .05. ** p < .01. WTAR (Wechsler Test of Adult Reading), Digit span B/W (digit span backwards).

### Regression 4.

### EARS item 2: I forget to do my exercises

| Variable | B | SE B | β | Sig. |
|---|---|---|---|---|
| Age | -.015 | .016 | -.142 | .341 |
| Gender | .848 | .418 | .273 | .047* |
| Education | .153 | .488 | .047 | .755 |
| WTAR | -.007 | .020 | -.062 | .724 |
| Stroop test | -.019 | .017 | -.173 | .255 |
| Zoo Map test | .264 | .167 | .210 | .119 |
| Digit span B/W | .047 | .108 | .064 | .666 |
| $R^2$ | | .130 | | |
| F | | 1.264 | | |

*Note.* * p < .05. ** p < .01. WTAR (Wechsler Test of Adult Reading), Digit span B/W (digit span backwards).

## Regression 5.

### EARS item 3: I do less exercise than recommended by my healthcare professional

| Variable | B | SE B | β | Sig. |
|---|---|---|---|---|
| Age | -.034 | .019 | -.267 | .076 |
| Gender | .749 | .490 | .205 | .132 |
| Education | -.592 | .573 | -.154 | .306 |
| WTAR | -.004 | .024 | -.031 | .863 |
| Stroop test | -.022 | .020 | -.168 | .267 |
| Zoo Map test | .281 | .196 | .190 | .157 |
| Digit span B/W | -.020 | .127 | -.023 | .876 |
| $R^2$ | | .136 | | |
| F | | 1.328 | | |

*Note.* * p < .05. ** p < .01. WTAR (Wechsler Test of Adult Reading), Digit span B/W (digit span backwards).

## Regression 6.

### EARS item 4: I fit my exercises into my regular routine

| Variable | B | SE B | β | Sig. |
|---|---|---|---|---|
| Age | -.002 | .015 | -.020 | .899 |
| Gender | .229 | .404 | .081 | .572 |
| Education | -.222 | .472 | -.074 | .640 |
| WTAR | -.010 | .020 | -.092 | .623 |
| Stroop test | -.002 | .016 | -.024 | .880 |
| Zoo Map test | .036 | .161 | .031 | .825 |
| Digit span B/W | .083 | .105 | .123 | .429 |
| $R^2$ | | .030 | | |
| F | | .261 | | |

*Note.* * p < .05. ** p < .01. WTAR (Wechsler Test of Adult Reading), Digit span B/W (digit span backwards).

## Regression 7.

## EARS item 5: I don't get around to doing my exercises

| Variable | B | SE B | β | Sig. |
|---|---|---|---|---|
| Age | -.014 | .017 | -.120 | .414 |
| Gender | .979 | .449 | .289 | .033* |
| Education | -.248 | .525 | -.070 | .639 |
| WTAR | -.024 | .022 | -.188 | .284 |
| Stroop test | -.018 | .018 | -.147 | .327 |
| Zoo Map test | .340 | .180 | .248 | .063 |
| Digit span B/W | -.014 | .116 | -.017 | .907 |
| $R^2$ | | .154 | | |
| F | | 1.531 | | |

*Note.* * p < .05. ** p < .01. WTAR (Wechsler Test of Adult Reading), Digit span B/W (digit span backwards).

## Regression 8.

## EARS item 6: I do some, but not all, of my exercises

| Variable | B | SE B | β | Sig. |
|---|---|---|---|---|
| Age | -.024 | .014 | -.225 | .099 |
| Gender | 1.175 | .380 | .376 | .003 |
| Education | -.977 | .445 | -.298 | .032 |
| WTAR | -.013 | .019 | -.113 | .481 |
| Stroop test | -.003 | .015 | -.026 | .848 |
| Zoo Map test | .256 | .152 | .202 | .098 |
| Digit span B/W | -.005 | .099 | -.006 | .963 |
| $R^2$ | | .288 | | |
| F | | 3.409 | | |

*Note.* * p < .05. ** p < .01. WTAR (Wechsler Test of Adult Reading), Digit span B/W (digit span backwards).

## Appendix 20. EARS Qualitative Data (Study 3)

**'In your own words, please can you explain why you have, or have not, done your exercises?'**

Participant 5: I have continued with the exercises in the hope that they will strengthen my back and ease my pain for a long period.

Participant 8: I do my back exercises to see if my back pain will ease

Participant 14: The only time I don't do exercises is when pain is really bad.

Participant 15: Not motivated enough even though should be. When pain gets less-even less motivation to do them. Can't be bothered. Determine to try and get into habit of doing them.

Participant 24: I have to do it because my back means my life. Without my back I haven't got life, no future. No comfort. That is the key of my condition. I got pain now but I will never give up to getting better. My back is priority of my life. I will do the exercises even if I get into 100% good condition. Thanks.

Participant 25: If there's an early appointment that prevents me from doing my exercises (I do them in the morning) then I may get round to doing them that day

Participant 26: I do my exercises and get my grandchildren to join in with me when they are here, otherwise I do them by myself.

Participant 27: Not particularly well motivated

Participant 28: I do exercises because I want to stop feeling pain and discomfort

Participant 29: I do my exercises at home because it makes me more active, happy and less pain on back and joints

Participant 30:

1. Making time is difficult
2. baby
3. handouts are not similar/ same exercises done in class-therefore lack of confidence when doing/thinking/of doing
4. =more instruction on 'How' to recognise doing exercises wrong, other than 'pain'

Participant 32: because it is going to make my back better

Participant 33: I do them outside of class and looking into another activity that I will enjoy doing. Have also been referred by Gp to healthy heart and healthy living who are working with me on lifestyle changes which includes diet and exercise for life.

Participant 35: I do try to do a few everyday

Participant 41: because it helps to feel better at times. So I do it often as possible, which is every day.

Participant 43: I try my best but a working mum of 4 it is not always easy to find time or a suitable place. So I keep active as much as I can.

Participant 44: it improves my back a small amount so I am able to get out of bed

Participant 48: lack of time (work and travel)

Participant 49: Time. I'm very busy due to full time work and looking after kids

Participant 52: do my exercise regularly- weather may sometimes affect desire to go swimming.
Only recently started swimming since attending back classes

Participant 53: usually do what you can every morning or evening.

Participant 54: lack of motivation. I prefer to exercise in company. I have now started to go to the swimming baths to do exercises once a week.

Participant 56: The pain becomes too much to concentrate and I cannot focus on how to perform exercises

Participant 57: they strengthen my back, I believe that when the muscles in the back are strengthened the pain will go away.

Participant 58: It's boring

Participant 64: I've reached the age I have to change my lifestyle and this has spurred me to continue. I can't let this hiccup in my life ruin the rest of my years. This has encouraged me to take up running.

Participant 69: I am doing my exercises outside my back class but does not seem help. My back is the same

Participant 70: as I mentioned my family commitments sometimes prevent me from completing the exercises

Participant 72: learning about how the back works and how to do the exercises has helped me cope.

Participant 75: I find it hard without painkillers

Participant 77: sometime it's painful
Sometime I forget
Sometime I only do a few a days; the physio said this is ok

Participant 78: because I do not have the time and feel the improvement

Participant 86: time constraints

Participant 90: I find some of the exercises too painful and get angry that I cannot do it.

Participant 91: I am too tired and don't feel like doing them. I don't have the space where I live with my flatmates.

Participant 92: It's a waste of time really, I feel like I am rushing around and still in pain

Participant 96: if I haven't got the time during the day but it is very rare that I do not do it. If I have to go out for the day and come back tired then can't do them. Also if I am feeling ill then I wouldn't do them. As long as I'm feeling up to it I do it.

Participant 97: I was able to do most of my home exercise routine as prescribed by a health professional until I attended a series of back pain sessions. Then initially it was more difficult because of pain and fatigue. After the third session I badly sprained the ankle on my bad leg and strained tendons and ligaments on both sides, therefore my progress was interrupted. Although I did the exercises prescribed by the doctor in A&E. I resumed the back class after my fall, increased my leg pain on all the exercises except one. The next class was less painful and more beneficial. I am still recovering from my ankle injury, but have restarted my initial home exercises, as far as possible. I have one more class to attend.

## Appendix 21. Backcare advert (Study 2)

**Do you have long-term lower back pain? We are looking for "expert patients" who would be happy to give their opinion on research in this area?**

Hi, I am Naomi and I am doing research with people with chronic lower back pain (i.e. pain for 3 months or longer). I am hoping to find some people with chronic lower back pain who are interested in research, and would be willing to inform and be involved in a study about lower back pain.

I think that it's really important that researchers speak to the population of people they are studying, so that they can better understand what factors are most important to focus on. This should make the results of any research more applicable to people with chronic lower back pain, and also benefit their future treatment.

Please email me at naomi.beinart@kcl.ac.uk or call me on 020 7848 6679
Alternatively you can email emma.godfrey@kcl.ac.uk or call her on 020 7188 0174

## Appendix 22. EARS Qualitative Data (Study 2)

**'In your own words, please can you explain why you have, or have not, done your exercises?'**

Participant 2: When I had feedback, I did it. Then I stopped. I'm not accountable to anyone. Pain is a physical reminder to exercise. Now, I have barely any pain.

Participant 3: I work 6 days a week. I forget. I get too tired.

Participant 5: I have ongoing pain. Demotivated, no real results. Lack of interest by physios-only input is for acute episodes. I think it would be good to be kept on books and to be seen every few months if I have ongoing back problems, especially acute episodes. This may prevent acute episodes as someone is keeping an eye on my progress.

Participant 7: I do the exercises because I want to stop feeling pain and discomfort.

Participant 8: Around 4 months ago, initially due to work commitments (working overtime and not having had time to exercise) and subsequently not having got back to my usual gym/exercise routine having had been travelling constantly. Also, fractured my toe earlier in the year which prevented me from going running and thus fell out of the gym pattern. Life had just taken over. I will need to get back to my routine to I have included the additional back exercise recommended by the physio. Hopefully that will help to keep my back in working order.

Participant 9: Was allocated another physiotherapist in whom I lost confidence as the exercises given by him were worsening my pain.

Participant 10: The exercises are boring and tedious and I don't feel confident that the physio really knew what was causing my pain or looking at my problems holistically. I felt I was being given generic exercises.

Participant 11: The pain tends to reduce after I have exercised a little for a few days. But, I go in phases, depending on what else if going on in my life.

Participant 15: I stop doing the exercises when the pain gets much worse. Sometimes I had no time or felt very tired.

Participant 17: Stopped 2 months ago. Lack of space. General lack of interest in physical activities

Participant 31: Stopped doing exercises when pain got better and just fell out of the routine. Since moving work location, work has been much busier so I'm very active at work.

Participant 33: I can feel and see progress afterwards. I am able to stretch further and feel more supported when training purely because I know how my body should react and how it should feel under normal circumstances.

Participant 42: I have because it makes my back feel OK for a short period of time; however I have not done all of the exercises because, if I strain too much, it makes the pain worse.

Participant 43: I continue to do my exercise, despite being very busy, because I know that it helps with my back.

Participant 45: I don't get around to doing the exercises the physio gave me as I keep forgetting exactly what I'm meant to do. But I do try and keep active in general. I have a bad memory.

Participant 49: I find that they really help my back pain and help me be able to do more with my kids. I try and do them at any opportunity.

Participant 52: My back hurts most of the time so I don't tend to do much exercise.

Participant 57: Generally I'm in pain, but I think it's because I sit down a lot at work. I do try and exercise, but I forget or I'm too tired or sore.

Participant 58: Busy life, too much to do most days, let alone exercise.

Participant 60: I used to see a physio who I got on really well with and she really understood all of my problems. But now I saw I think a student or something. She was quite young and I don't think she really understood where I was coming from. I don't really understand the exercises she asked me to do.

Participant 65: They make my back feel much better.

Participant 71: I'm very busy and priorities change every day. Some days I exercise is not a priority.

Participant 74: Motivation. I don't really have any.

Participant 79: Bored. Better things to do. Tired a lot.

Participant 84: I try and exercise outdoors, but a lot of the time weather gets in the way. I also don't like to be out after dark, so at certain times of year I have to think of something else. I don't really like swimming.

Participant 91: It make it possible for me to get around and up the stairs without getting worried that I'll make it up and not be able to get down. I do them every morning in bed and then after my tea. I couldn't get around without doing them every day. I have flare-ups like I do now, but then I take pain-killers and slow down some of the exercises for a while.

Participant 103: I try as I know they help my back feel like it has more movement, but on the other hand, sometimes they make my back hurt more, like after a physio appointment when I tend to feel sore for a couple of days. I know it's a good pain as it's doing good things for my back, but it's still uncomfortable.

Participant 116: I actually quite like doing them.

Participant 118: Only do them when I have taken Nurofen, but sometimes try and do them in the evening too if I have not been very active during the day.

Participant 120: It's not that I don't do them, but just that sometimes I forget and then it's too late as I'm in bed or out locally so I'm busy and can't really do them when I'm out and about.

Participant 128: The physiotherapists knows much better than me what I should be doing so I try and do what I'm told, when I remember anyway. I do find that my back is better when I do them.

Participant 129: Makes my pain a bit less.

Participant 130: My back gets so sore and then the rest of me starts to get sore. I can't exercise when I feel like that. Hard to be motivated when all you can think about is being sore and not being able to sleep because you have to keep moving every 10 minutes otherwise you get stuck.

Participant 138: I live in quite a small flat with a large family, so it's a bit cramped. If I'm not too tired I try and do my exercises in the evening when it's a little quieter and no-one really notices what I'm doing. Depends on lots of things really.

Participant 140: I have a list of things I mean to do every day and quite a few of them are higher on my list than exercise. I am a member of a gym and I do go sometimes.

Participant 142: In too much pain.

Participant 147: I have done them over the last week more than I thought I would. But they were easier than the last lot of exercises I was told to do. Can't guarantee I'll do them this week. We'll have to see.